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ENVIRONMENTAL CONSERVATION

Guidelines for Evaluating New Development in Contra Costa County



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Energy Conservation: Guidelines For Evaluating New Development In Contra Costa County, California

VOLUME 2:

Contra Costa County Energy Resources and Conservation Study

prepared by

Interactive Resources, Inc.
Point Richmond, California

for the

Contra Costa County Planning Department
Martinez, California

May 1976

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INTRODUCTION

In recent years, the need for conservation of scarce energy resources has become an important matter of concern. Concurrently, there has been an increasing recognition that the general patterns of urban development, as well as the specific characteristics of buildings, can have an important effect on the way that energy is used.

In recognition of this need to plan for energy-conserving development, the State of California has required that new projects in the state should be evaluated to determine their effect on energy consumption, with an identification of ways to reduce wasteful use of scarce fossil fuels. This report provides detailed guidelines for making energy evaluations of new projects and is intended to serve as a supplementary manual to the state guidelines for environmental impact report preparation. In addition, this report is intended to make information on energy use and conservation available to developers, design review boards and others involved in the development process.

Emphasis of study

In this report, there is a focus on the early stages of the development process—general plan amendments, zoning and subdivision review. Most existing research on energy evaluation deals with specific building projects; the energy implications of preliminary planning decisions generally have been overlooked. However, most of the environmental impact reports prepared by Contra Costa County and other county governments deal with land subdivision, rezoning and amendment of general plans, and this study is a response to the need for guidance for making evaluations for these types of proposals. The final chapter of this report includes some information on evaluation of specific building projects, but the main emphasis in that chapter is on identification of existing research on energy evaluation of buildings.

Relation to other study components

This report is the second of three volumes dealing with energy use in Contra Costa County. Volume 1 deals with the existing local energy situation, including current consumption characteristics as well as future prospects for conventional and alternative energy sources. In recognition that existing development will continue to have a decisive effect on energy use for some time, Volume 3 includes an energy analysis and recommendations for a number of existing County buildings, intended as prototypes to demonstrate

ways that energy could be conserved in existing urban development.

Report organization

Before launching into specific methods of analysis, an outline of basic energy evaluation concepts and sources of information is included in Chapter 1. The limitations of these data sources are stressed, along with the need for further basic research.

The remaining three chapters of the study are organized in order of increasing detail of development, ranging from basic land use decisions (rezoning and general plan amendments) to energy evaluation of subdivisions and building projects. Inevitably, there is considerable overlap among these chapters, although there has been an effort to keep duplication to a minimum.

Within each chapter, the evaluation process has been divided into four phases. In Phase 1 methods are outlined for collecting background information necessary for making the evaluation; Phase 2 involves the calculation of long-term energy impact. Phase 3, the most important segment of the evaluation process, provides a method of identifying energy conservation problems, together with possible alternatives and mitigation measures to conserve energy. These energy-saving suggestions are summarized in a checklist within each chapter. Phase 4 then provides guidance on the final preparation

of the energy component of an environmental impact report.

Funding and report preparation

In addition to funding by Contra Costa County, this study was financed in part by a federal grant from the United States Department of Housing and Urban Development, with the funds administered by the California Office of Planning and Research. Preparation of the report was a joint effort undertaken by the Contra Costa County Planning Department and Interactive Resources, Inc., a multidisciplinary firm of planners, architects and engineers specializing in energy management and located in Point Richmond, California. Valuable contributions to this study were also made by many other government agencies, utility companies and individuals.

1 Basic Energy Concepts and Sources of Data

In this chapter, the principles used in analyzing energy use are outlined. Sources of basic energy information used in this study are identified, along with some of the limitations encountered in the formidable task of attempting to understand how energy may be wasted or conserved in the process of urban development.

Energy accounting: the science of energetics

In looking at the direct and hidden energy costs of urban development, it is useful to apply the principles of energetics, or net energy accounting. For several decades scientists have been studying the flow of energy in the natural environment. Recently, the science of energetics has been systematically applied to human activities, and research in this area has gained momentum since the arrival of the "energy crisis."

Howard Odum's book, Environment, Power and Society¹, provides a comprehensive guide to the principles of energetics. In this book Odum stresses the need for a "network language" for analyzing environmental systems. Odum notes that, "to understand a whole system and the full interaction of the parts, we must use a common denominator that expresses all the flows

and processes together." Odum uses power, or the rate of flow of useful energy, as this common denominator.

To express the energy flows that represent the parts and relations of all systems, Odum makes use of the energy flow diagram (also called the energy network diagram or power circuit diagram). The energy flow diagram includes inputs (such as fuel or food), outputs (such as a crop yield), energy storage within the system (such as fuel tanks) and other symbolic notation.

In this study, the primary focus will be on the energy inputs required for urban development. However, it is important to keep the idea of total energy flow in mind, particularly where useful energy outputs from agricultural land may be eliminated.

¹Odum, Howard, Environment, Power and Society (New York: Wiley-Interscience, 1971), p. 21.

Measurement of energy

For consistency with the State of California's format for energy analysis (as outlined in the revised environmental impact report guidelines), the British Thermal Unit (BTU) has been used as the basic energy unit in this study. Since measurements of large-scale energy use often range into billions of BTU's or more, energy use tables in this study often are expressed in therms; one therm equals 100,000 BTU's. While the therm is commonly associated only with natural gas consumption, this unit of energy is used in this study for general measurement of energy use. Macro-scale energy consumption figures often go so far as to refer to one quadrillion BTU's (1,000,000,000,000) as a "quad." The kilocalorie is the basic metric unit of energy measurement; one kilocalorie equals about four BTU's. Conversion tables for various units of energy measurement are included in Appendix E.

While the words "power" and "energy" are often used interchangeably, it is important to keep their distinction in mind. Power is defined as the rate of flow of useful energy. While energy is measured in units of heating ability (such as BTU's), power is measured in time units (such as BTU's per year).

Categories of energy input

In this study, direct energy inputs refer to fuels actually consumed at the point of use, such as the quantity of fuel used in heating a home. Indirect or hidden energy inputs include the energy which is "built into" the product before the point of use, such as the fuel consumed in mining coal or manufacturing a light pole. Total energy input is the sum of direct and indirect energy input.

In urban development, energy consumption can also be divided in two basic categories. Initial energy input includes fuel used for "front-end" improvements, such as building streets for a subdivision. Long-term energy input refers to continuing energy requirements spaced out over a period of time, such as on-going fuel use for home heating, or construction of homes over a period of years.

Total energy inputs for urban development

In this study, reliance has been placed on a detailed survey research document prepared by the Center for Advanced Computation (C.A.C.) at the University of Illinois. This report, entitled Energy Cost of Commerce Goods, 1963 and 1967¹, is a landmark study of energy flows in the American economy. The research is based on the principle that every flow of economic goods requires an energy investment, from processing of raw materials to retail sales of the finished product. The energy inputs of administrative functions (lighting and heating office buildings, for example) are thus included as part of the total energy cost of a product or service.

Based on the principle that energy inputs are directly related to dollar costs, the total energy input is measured in BTU's per dollar cost to the producer of the product or service. Calculations on this basis were made for 357 types of products and services, representing many sectors of the American economy. In addition, the energy input needed to produce various fuels was calculated.

¹Herendeen, Robert A., and Bullard, Clark W., III, Energy Cost of Commerce Goods, 1963 and 1967 (Urbana, IL: Center for Advanced Computation, University of Illinois at Urbana-Champaign, November 1974), p. 15.

In Table 1.1 the energy costs for various goods and services related to urban development have been summarized. In addition to the original energy inputs per 1967 dollar (from the C.A.C. study), the table includes updated energy input figures per 1975 dollar. A number of indices, reflecting the inflation of costs from 1967 to 1975, have been used in calculating these revised figures. Since costs of goods and services are continuing to rise, further adjustment of these energy costs may be necessary at the time of project analysis.

The energy input needed to produce various fuels is indicated in Table 1.2. For example, each BTU of natural gas requires as indirect input of 1.1 BTU's for production. The data in this table underscores the long-term problem of relying on fossil fuels which required more energy to produce than they provide as fuel.

While the data in these tables can be valuable in understanding total energy inputs, several drawbacks should be noted. First, the information is based on 1967 conditions; although the cost figures have been updated, changes in technology may have altered the energy used in production of certain goods. Second, the information reflects nationwide averages; energy costs of commodities such as water may vary widely from region to region. Third, caution must be used in selecting the dollar cost of an item. The values in the table refer to producers' costs; thus, the manufacturer's cost of producing a good must be added to the

retailer's cost to "produce" retail services in selling the product. Finally, it should be noted that these dollar costs should not include items, such as speculative land value, which have not required an energy input.

The following example, from the C.A.C. research report, illustrates how the information in Table 1.1 can be used to calculate energy input:

Computing the energy cost of an electric mixer illustrates the relative roles of the energies to manufacture and operate the device. In 1963¹, an average mixer cost \$20 retail. To be exact, we should separate the transportation and trade margins from the manufacturer's price, and apply the appropriate energy intensities. For simplicity we assume that all of the margins are allocable to retail trade (I/O sector 69.02). Electric mixers belong in sector 54.04, electric housewares and fans. Then the energy cost to manufacture and sell the mixer is

$$0.6 (84,400) + 0.4 (35,200) \times 20 = 1.29 \times 10^6 \text{ BTU.}$$

¹This particular example was based on 1963 energy input tables.

Assuming that the mixer lasts 14 years, with no maintenance or disposal costs, the yearly energy impact of manufacture and sale is 9.2×10^4 BTU A typical mixer uses about 10 kwh of electricity per year (125 watts, 13 minutes per day). Taking into account the inefficiency of electricity generation and delivery², this is 1.33×10^5 BTU/yr. Then the total yearly energy impact of the mixer is

$$1.33 \times 10^5 + 9.20 \times 10^4 = 1.33 \times 10^5 (0.59 + 0.41) \text{ BTU.}$$

59% results from operating the device;
41% from producing it.³

Other examples of using this data in calculating energy input for urban development are included in the case study at the end of Chapter 3.

²See Table 1.2, page 1-7.

³Herendeen, Energy Cost of Commerce Goods, 1963 and 1967, p. 15.

TABLE 1.1
ENERGY COST OF SELECTED GOODS AND SERVICES
(BTU/DOLLAR UNIT OF FINAL OUTPUT)

SECTOR I, D.	INDUSTRY	BTU/DOLLAR		PRICE INDEX	SOURCE
		1967 ¹	1975	% INCREASE 1967-1975	
205	Vegetables, Miscellaneous Crops	42,738	24,000	79	7
1101	New Construction, Residential	55,093	28,000	94	4
1102	New Construction, Nonresidential	67,206	36,000	88	4
1103	New Construction, Public Utility	79,610	36,000	88	4
1104	New Construction, Highway	117,400	51,000	130	6
1105	New Construction, Other	86,662	41,000	112	3, 5
1201	Maintenance Construction, Residential	50,043	26,000	91	2
1202	Maintenance Construction, Other	57, 108	30,000	88	4
2702	Fertilizers	173,931	101,000	72	7
3102	Paving	562,526	236,000	138	6
3103	Asphalt	482,118	210,000	130	6
3601	Cement	480,161	197,000	144	6
3605	Clay Products	259,949	172,000	51	7
3611	Concrete Products	142,050	64,000	123	6
3612	Ready-Mix Concrete	180,661	31,000	123	6
4002	Plumbing Fittings	74,907	47,000	59	7

4208	Pipe	74,272	36,000	109	7
4501	Construction Machinery	68,040	36,000	91	7
5302	Transformers	73,545	53,000	40	7
5303	Switchgear	46,444	28,000	65	7
5805	Electrical Equipment	63,808	45,000	43	7
6600	Communications	17,405	14,000	26	2
6803	Water, Sanitary Service	108,371	62,000	74	2
6902	Retail Trade	35,413	23,000	52	2
7301	Misc. Business Service	26,996	18,000	54	2
7303	Misc. Professional Service	24,991	16,000	54	2

SOURCES

1. Herendeen and Bullard, Energy Cost of Commerce Goods, 1963 and 1967, Center for Advanced Computation, University of Illinois at Urbana-Champaign, Document No. 140, November 1974.
2. United States Department of Labor, Bureau of Labor Statistics, Consumer Price Index, October, 1975.
3. Lee Saylor, Inc., Construction Cost Newsletter, October, 1975.
4. "Building Costs," Architectural Record, McGraw-Hill, Inc., October, 1975, and February, 1968. (Tables compiled by Dodge Building Cost Services, McGraw-Hill Information Systems Company.)
5. "3rd Quarter Cost Roundup," Engineering News Record, McGraw-Hill, Inc., September 18, 1975, p. 64. (Building Cost and Price Indexes from Engineering News Record, U. S. Commerce Department, Bu Rec, Dodge Building Cost, Factory Mutual Industrial Buildings, Means Construction Costs, etc.)
6. California Highway Construction Cost Index, CALTRANS, 16 October 1975.
7. Monthly Labor Review, Department of Commerce, Bureau of Labor Statistics, November 1975, (Wholesale Price Index and Price Indexes for the Output of selected SIC Industries).

TABLE 1.2
ENERGY REQUIREMENTS FOR
PRODUCTION OF FUELS AND ELECTRICITY¹

<u>Category</u>	<u>Energy Input</u> (BTU input per BTU of product)
Mined coal	1.01
Refined petroleum products	1.21
Electric power ²	3.80 (3.226)
Natural gas	1.10

¹Herendeen, Energy Cost of Commerce Goods, 1963 and 1967,

²P G and E uses a figure of 3.226 BTU input for an output of 1.0 BTU of delivered electrical energy.

Calculations of energy inputs for residential development

In April, 1974, the U. S. Government published the first comprehensive report on the economic costs and environmental impacts associated with alternate densities and types of development at the urban fringe.³ The authors of The Costs of Sprawl devoted considerable research to developing analytical prototypes which represent characteristic high standard, new suburban construction in typical environmental settings. These neighborhood prototypes have been used in this study as a basis for analyzing the energy inputs for a range of project types. A summary of these neighborhood housing types is shown in Table 1.3, and Figure 1.4 gives a graphic indication of the representative development patterns.

The economic costs of such land development components as streets, utilities and communications were given in The Costs of Sprawl as 1973 dollars calculated as national averages. Using a variety of local sources, these costs were updated to reflect approximate local conditions in late 1975. Then, by combining these dollar costs with the energy input per dollar for various commodities (Table 1.1), predictions of total

³Real Estate Research Corporation, The Costs of Sprawl (Washington, DC: U.S. Government Printing Office, 1974).

energy input per dollar for various components of urban development could be made.

These predictions have been consolidated and summarized in Tables 1.5, 1.6 and 1.7, which are intended to provide input for the total energy projection calculations in Chapter 2 and Chapter 3.

A set of more detailed tables in Appendix A traces the derivation of these figures back to the original sources (see Figure 1.8).

The total energy input figures obtained in these procedures should not be treated as precise data; much more detailed research would be necessary, based on local conditions. However, this data is seen as providing a tool for gaining a rough idea of total energy usages in a project, as well as providing a basis for further research.

Energy input for non-residential development

Non-residential development characteristics vary widely with the characteristics of a particular project. However, an attempt was made in this study to determine average operating energy use for non-residential development based on information gathered in the Building Energy Utilization phase of this study (Volume 3) and summarized in Table 1.7.

A very generalized calculation of initial energy input for construction can be made if the total cost of the project is known. From Table 1.1, each dollar spent on non-residential construction in 1975 represents an average input of 36,000 BTU's. Adjustment of this figure for inflation can provide a guide for initial energy input of the project.

TABLE 1.3
NEIGHBORHOOD HOUSING TYPES

	A Single-Family Conventional	B Single-Family Clustered	C Townhouse Clustered	D Walk-Up Apartment	E High-Rise Apartment	F Housing Mix (20% Each A-E)
<u>Dwelling Units</u>	1,000	1,000	1,000	1,000	1,000	1,000
Average Floor Area Per Unit (square foot)	1,600	1,600	1,200	1,000	900	1,260
<u>Total Population</u>	3,520	3,520	2,220	2,220	2,825	3,300
Persons per Unit	3.5	3.5	3.3	3.3	2.8	3.3
<u>School Children</u>	1,300	1,300	1,100	1,100	300	1,100
<u>Total Acreage</u>	500	400	300	200	100	300
Residential	330	200	100	66	33	145
Open Space/Recreation	45	90	90	73	32	66
Schools	29	29	26	26	15	26
Churches	5	5	5	5	5	5
Streets and Roads	75	60	45	30	15	45
Vacant	16	16	34	0	0	13
<u>Residential Density</u>						
Units per Gross Acre	2	2.5	3.3	5	10	3.3
Units per Net Residential Acre	3	5.0	10.0	15	30	6.9

Source: The Costs of Sprawl, page 6.

FIGURE 1.4
NEIGHBORHOOD DEVELOPMENT PATTERNS

NEIGHBORHOOD PROTOTYPES - LEGEND



SINGLE FAMILY CONVENTIONAL



SINGLE FAMILY CLUSTERED



TOWNHOUSES CLUSTERED



WALK-UP APARTMENTS



HIGH RISE APARTMENTS



PUBLIC FACILITIES



RECREATION



VACANT LAND

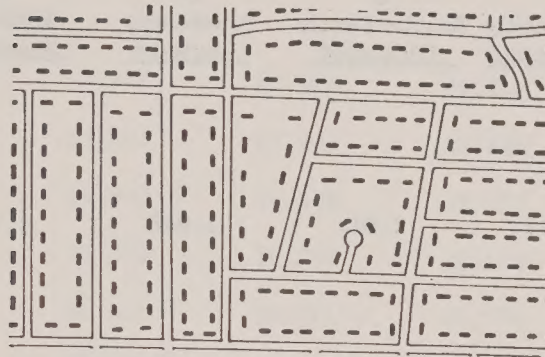


PUBLIC AND SEMI PUBLIC
OPEN SPACE



UNDEVELOPED LAND

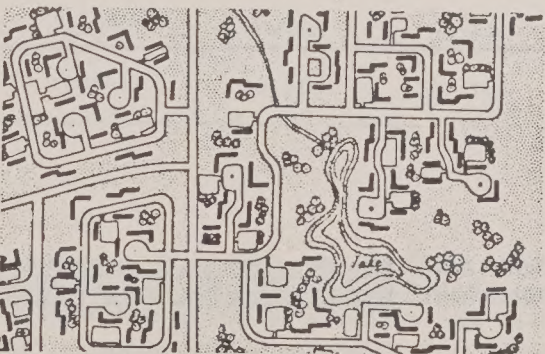
SINGLE FAMILY
CONVENTIONAL
100 ACRES



SINGLE FAMILY
CLUSTERED
100 ACRES

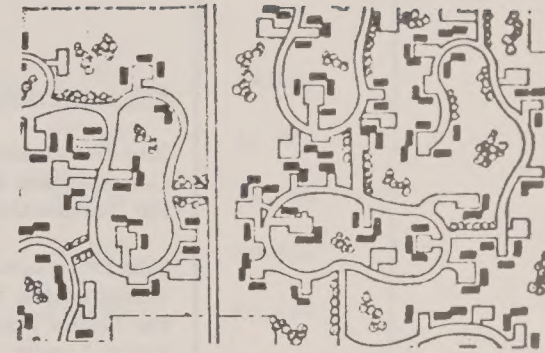


C. TOWNHOUSES
CLUSTERED
100 ACRES

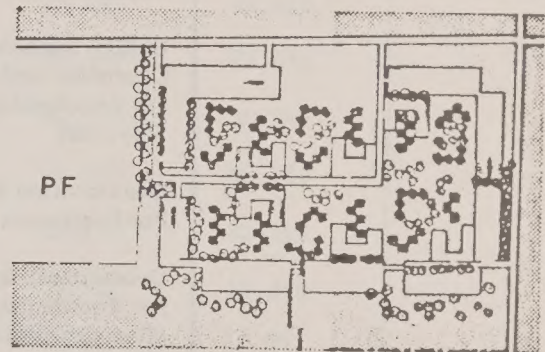


500 FEET

D. WALK-UP
APARTMENTS
100 ACRES



E. HIGH RISE
APARTMENTS
100 ACRES



F. HOUSING MIX
(20% EACH A-E)
100 ACRES



0 500 FEET

TABLE 1.5

CONSOLIDATED ENERGY INPUT DATA
(Direct and Indirect)

	A <u>Single-Family Conventional</u>	B <u>Single-Family Clustered</u>	C <u>Townhouse Clustered</u>	D <u>Walk-Up Apartment</u>	E <u>High-Rise Apartment</u>	F <u>Housing Mix (20% Each A-E)</u>
<u>BTU x 100,000</u>						
Site Development ¹ Construction Inputs Per Residential Unit	3,825	2,841	2,048	1,383	750	2,228
Site Development ² Construction Inputs Per Linear Foot of Street Length	63	63	72	90	11	8
Utility Infrastructure ³ Operation and Maintenance Per Residential Unit (20-year)	1,331	1,357	1,174	1,091	887	1,197
Construction Inputs ⁴ Per Residential Unit	14,511	11,056	7,452	6,070	9,621	9,260
Operational Inputs Per Residential Unit (Gas and Electricity— 20-years)	- - - - - varies according to location; see Table 1.6 - - - - -					

Notes:

¹For sources and details see Table A.15, Site Development Construction Inputs Per Residential Unit.

²For sources and details see Table A.16, Energy Inputs Per Linear Foot of Street For Alternate Neighborhood Housing Types.

³For sources and details see Table A.17, Operation and Maintenance, Energy Input Per Residential Unit Per Year.

⁴For sources and details see Table A.19, Construction Energy Inputs Per Residential Unit.

TABLE 1.6

ENERGY INPUTS FOR RESIDENTIAL BUILDING OPERATION
OVER A 20-YEAR PERIOD
(BTU x 100,000)

Geographical Area	A Single-Family Conventional	B Single-Family Clustered	C Townhouse Clustered	D Walk-Up Apartment	E High-Rise Apartment	F Housing Mix (20% Each A-E)
<u>BTU x 100,000</u>						
Antioch	41,228	41,228	30,857	27,495	27,019	33,565
Clayton	57,931	57,931	43,601	39,118	38,691	47,455
Concord	44,999	44,999	33,257	29,163	28,218	36,129
El Cerrito	38,565	38,565	28,122	24,232	23,044	30,508
Hercules	35,011	35,011	25,791	22,527	21,708	28,008
Lafayette	60,544	60,544	44,412	38,573	36,974	48,210
Martinez	41,991	41,991	30,951	27,049	26,087	33,616
Moraga	71,962	71,962	52,343	44,959	42,616	56,768
Pinole	48,069	48,069	35,482	31,063	30,015	38,540
Pittsburg	41,513	41,513	30,729	27,002	26,179	33,388
Pleasant Hill	46,571	46,571	34,383	30,116	29,107	37,348
Richmond	35,300	35,300	25,802	22,306	21,280	27,997
San Pablo	35,333	35,333	35,475	21,624	20,245	27,603
Walnut Creek	54,912	54,912	40,176	34,777	33,222	43,600

Source:1. Natural Gas

20-year long-term commitment = BTU per residential unit per year x 1.1 x 20 years (where 1.1 = primary energy required to deliver an equivalent amount of gas at the point of consumption).

2. Electric Power

20-year long-term commitment = KWH per residential unit per year x 3.226 x 3412 BTU/KWH x 20 years (where 3.226 = primary energy required to deliver an equivalent amount of electricity at the point of consumption).

3. See page 205 of Appendix B for a general discussion of the methodology behind the estimates used for energy consumption in this table.

TABLE 1.7

SELECTED ENERGY INPUTS FOR NON-RESIDENTIAL BUILDING OPERATION
20-YEAR LONG-TERM COMMITMENT

BUILDING TYPE	BTUx100,000/SF/YEAR	BTUx100,000/SF/20-YEAR
Office Building - High Rise ¹	1.58	31.58
Office Building - Low Rise ¹	1.41	28.24
School ¹	0.87	17.34
Retail Structure ¹	4.19	83.80
Medical Facility - Privately-Owned ¹	3.00	60.02
Nursing Home ²	4.83	96.55
Library ²	2.65	53.09
Auditorium ²	1.68	33.53
Indoor Swimming Pools ³	9.16	183.26

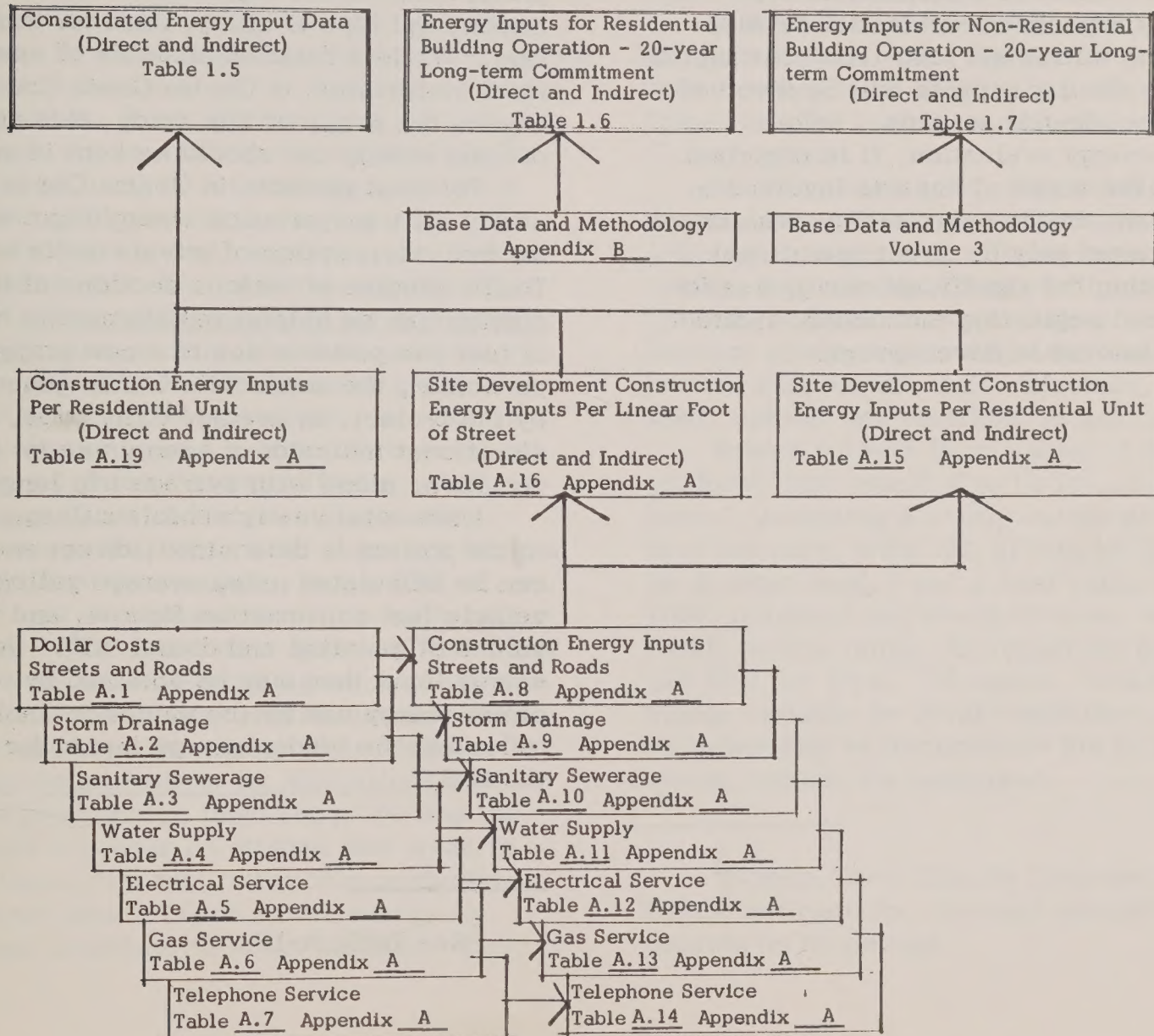
¹Source: Hugh Carter Engineering Corporation, Non-Residential Energy Conservation Standards, Title 24, Economic and Energy Effectiveness Study (Sacramento, CA: State of California Energy Resources Conservation and Development Commission, 5 November 1975). These projections were made in a study to determine the effect on energy consumption of the proposed California Prescriptive Standards for non-residential building use. An average of the San Jose projections was used in each case and multiplied by the primary energy ratio of 1.1 for gas and 3.226 for electricity. For reasons that were not apparent, the systems simulated in the study appeared to be more oriented toward electrical heating than what conventional practice would indicate. Perhaps the questionable long-term availability of natural gas was a factor in choosing electrical heating systems.

²Source: PGA Engineers, Incorporated, Florida Energy Conservation Manual (Tallahassee: State of Florida Department of General Services, March 1975). These projections are an average of the performance standards for each building type in eight different climatic areas of Florida. (Performance criteria are relatively unrelated to climate and therefore have applicability in California.) All systems are entirely electric and the site energy consumption has been multiplied by a primary energy ratio of 3.226.

³Source: Interactive Resources, Inc., Proposal Submitted to Energy Research and Development Administration by City of Richmond, California, for Richmond Municipal Natatorium Solar/Gas Integrated Energy System Demonstration Project (Richmond: Interactive Resources, Inc., 26 November 1975). This projection is for an all-gas system with a primary energy ratio of 1.1. The consumption ratio is per square foot of pool surface area.

Figure 1.8

DERIVATION HIERARCHY FOR ENERGY CONSUMPTION PROJECTIONS



Identification of impacts for residential development

Table 1.11 includes a summary of the various energy impacts of residential development, including initial and long-term consumption requirements. Similar impacts will be involved for most non-residential projects. Before beginning an energy evaluation, it is important to understand the scope of impacts involved in new development; in the past, energy evaluations often have focused only on direct operational impacts, ignoring the significant energy use for construction and neglecting the hidden, indirect impacts built into urban development.

Energy inputs for transportation

The location and other characteristics of a project can have a significant effect on the amount and type of energy used for transportation. While a detailed analysis of energy use for transportation in Contra Costa County was beyond the scope of this study, this component of total energy use should be kept in mind.

For most projects in Contra Costa County, nearly all transportation energy input will be for fuel consumption of private motor vehicles. Traffic studies of various sections of the country can be helpful in determining changes in fuel use patterns due to a new project. In particular, the automobile traffic generated by the project, in average daily trips, is a significant indicator of energy use for transportation, along with average trip length.

Once total yearly vehicle mileage attributed to the project is determined, direct energy use can be calculated using average gallon-per-mile vehicle fuel consumption figures, and the fuel values of gasoline and diesel oil¹. Indirect energy input then may be obtained by multiplying direct energy use by the values in Table 1.2, reflecting the hidden energy inputs for producing the fuel.

¹See Table A-18.

Energy inputs and outputs for agriculture and rangeland

In most cases, urban development takes place on land formerly used for some type of agriculture. To understand the energy implications of this shift in land use, it is important to determine the existing flows of energy on the site.

Although the previously-described C.A.C. study could be used in determining nationwide averages for total agriculture energy use, another detailed research report provides more specific information for California conditions. This report, Energy Requirements for Agriculture in California, is a recent, detailed analysis of the fossil-fuel and electrical energy input needed for mechanized agriculture, as well as the caloric content obtained from various crops.

In Table 1.9 the "energy efficiency" of various agricultural products is summarized. The table shows that most field crops are fairly energy-efficient; for example, every BTU of fossil fuel and electricity needed to raise barley produces 6.6 BTU's of food. However, most raw fruits and vegetables require as much or more energy to produce as they provide in food value.

Unfortunately, the energy input figures from Energy Requirements for Agriculture do not reflect the total energy input for producing the crop. While a concerted attempt was made to trace the fossil fuel inputs for crop production, some indirect inputs (such as the energy to produce farm machinery and the indirect energy

input to produce fossil fuels) were not included. Thus, these agricultural energy use figures should only be compared with direct yearly energy input for urban development.

If more inclusive information on total energy input is desired, cost figures for crop production, from University of California extension publications, may be used in combination with the C.A.C. study.

In comparison with urban development, direct inputs of energy per acre would be negligible for grazing land. These minor inputs could include motor vehicle fuels for hauling and range upkeep, and electricity for water pumping. Indirect energy inputs might also be needed for protein supplement, salt, minerals, supplementary feed, upkeep and veterinarian and office expenses.

Energy outputs (food value) of rangeland-produced beef would also be low, on a per-acre basis. Assuming a yearly output of 70 pounds of beef per acre, with 50% of this weight available as dressed beef,¹ and a food value of 6.4 BTU's (1600 calories) per pound of meat, an average yearly energy output for rangeland might be about 225 BTU per acre. Of course, these figures are highly variable for local conditions, and are included only to demonstrate the relatively minor energy outputs for rangeland.

¹Contra Costa County Cooperative Extension Office estimate for cow-calf operation with winter grazing on rangeland.

TABLE 1.9

FOSSIL FUEL REQUIREMENTS AND ENERGY OUTPUTS FOR SELECTED AGRICULTURAL COMMODITIES
(California, 1971)

CROP CALORIC CONTENT (A) FUEL AND ELECTRICAL ENERGY INPUT (B)			
COMMODITY	1,000 KCAL/TON*	1,000 KCAL/TON*	ENERGY EFFICIENCY (A/B)
<u>FIELD CROPS</u>			
Barley	3166.	479.	6.6
Beans, Dry	3084.	2683.	1.2
Corn (excluding drying)	3338.	1027.	3.3
Rice	3293.	1289.	2.6
Sorghum, Grain	3012.	1189.	2.5
Wheat (Flour)	3021.	563.	5.4
<u>RAW VEGETABLES AND FRUITS</u>			
Beans, Green	1116.	2048.	0.5
Broccoli	290.	1179.	0.2
Carrots	381.	360.	1.1
Cauliflower	245.	986.	0.2
Celery	154.	351.	0.4
Lettuce	163.	484.	0.3
Melons	236.	637.	0.4
Onions	345.	390.	0.9
Potatoes	689.	325.	2.1
Strawberries	336.	728.	0.5
Tomatoes	200.	262.	0.8
Apples	508.	401.	1.3
Apricots	463.	840.	0.6
Grapefruit	372.	1166.	0.3
Grapes	608.	577.	1.1
Oranges	463.	1089.	0.4
Peaches	345.	472.	0.7
Pears	553.	964.	0.6
Plums	599.	1651.	0.4
<u>DRIED FRUITS AND NUTS</u>			
Almonds	5425.	7087.	0.8
Prunes	3121.	4447.	0.7
Walnuts	5697.	10746.	0.5

* One BTU = 0.252 Kcal.

SOURCE: Cervinka, et. al., Energy Requirements for Agriculture in California.

Base period for calculating long-term energy use

Ideally, energy inputs should be calculated over the entire lifetime of the project. In the case of some types of development, this could be one hundred years or more. However, energy inputs for urban development have varied dramatically in the past, and this variability could be expected to continue into the future. Present assumptions about energy use can be rendered obsolete by changes in technology or cultural characteristics, and it is impossible to predict the nature of these changes. Consequently, a twenty-year base period has been chosen for calculating long-term energy use for a project. Over this period, there is a reasonable likelihood that basic assumptions regarding energy use will not become obsolete, and yet the twenty-year period emphasizes the need for a look at long-term energy commitments.

Delayed effect of land use decisions

All "indirect" land use decisions, including general plan adoptions, rezonings, and subdivision approval, will have a delayed energy impact, due to the lapse of time between the decision and the time of actual construction and occupancy. For example, well-located land rezoned for residential use could be completely "built out" within five years, while a similar rezoning on marginal land might result in only a few scattered homes on the property after twenty years. The intent of the developer, previous trends in the area, and observations by real estate economists may be considered in predicting the timing of development.

To calculate total energy input for a project over a twenty-year period, Table 1.10 can be used to take this delayed effect of land use decisions into consideration. For example, if a proposed ten-lot subdivision is estimated to be fully occupied within five years, there will be vacant lots during this initial period which will not be creating a demand for natural gas and other fuels. Over twenty years, the subdivision will thus require only 90% of the energy that would have been needed if the project would have been "built out" immediately.

TABLE 1.10a

"BUILD-OUT" FACTORS

With 100 per cent build-out
within 20 years

<u>Year of 100 per cent build-out</u>	<u>Build-out factor</u>
1	1.00
5	.90
10	.775
15	.65
20	.525

TABLE 1.10b

"BUILD-OUT" FACTORS

With less than 100 per cent
build-out in 20 years

<u>Per cent build-out at end of 20 years</u>	<u>Build-out factor</u>
100%	.525
80%	.420
60%	.315
40%	.210
20%	.105

TABLE 1.11

TOTAL ENERGY IMPACTS OF RESIDENTIAL LAND USE

ACTIVITY	DIRECT ENERGY INPUT	INDIRECT ENERGY INPUT
A. INITIAL ENERGY IMPACTS		
Site clearance and construction of streets, utilities and other site improvements.	Gasoline/diesel oil for access to site and operation of equipment. ¹	
B. LONG-TERM ENERGY IMPACTS		Indirect energy input for production of materials, equipment and transportation to the site will include a combination of various energy sources including coal, refined petroleum products, natural gas and electricity.
1. Construction of housing and neighborhood facilities (community buildings, swimming pools, etc.).	a. Gasoline/diesel oil for access to site and for operation of equipment. b. Electricity for operation of power tools.	
2. Operation of housing and neighborhood facilities.	a. Space and water heating. b. Space cooling. c. Electricity for operation of lighting and appliances.	
3. Maintenance and operation of streets, utilities and open space.	a. Gasoline/diesel oil for access to site and operation of maintenance equipment. b. Electricity for operation of power tools, street lighting, pumping stations, etc.	
4. Transportation.	a. Fuel for operation of private automobiles and other vehicles. b. Fuel for operation of delivery vehicles, public transportation, etc.	

Notes

¹ Although data contained in this report regarding energy inputs for construction includes both direct and indirect inputs, Table A18 has been included to provide an optional break out of the direct energy inputs for fuels used in street and highway construction. Direct energy inputs for fuel are not available for other types of construction.

2 Evaluation of Energy Impact: Basic Land Use Decisions

Every decision leading to the construction of a project in a particular location may have far-reaching energy implications. General plans, rezoning and land subdivision, as well as the ultimate construction of the project, are all commitments of varying degree to allocate energy resources. While general plans and zoning may be changed, these decisions often are the first steps in a chain of events which determines long-term energy commitments in a planning area.

While this chapter concentrates on the energy implications of rezonings and general plan amendments, Chapters 3 and 4 deal with the more detailed issues of subdivision and building project review. However, there is a good deal of overlap among these categories, and some suggestions for conserving energy in these subsequent chapters may also apply to a fairly detailed proposal for a land use change. Also, rezonings and subdivisions are often combined into a coordinated proposal, and the evaluation of the project may include more than one phase of development.

In preparing an energy component for a basic land use decision, it is important to concentrate on issues which are the responsibility of local governments. By establishing energy-efficient land use and circulation patterns, local governments can make a meaningful contribution to energy conservation, and these are the points that should be emphasized in evaluating a proposed rezoning or general plan amendment.

In this chapter, a method for preparing the energy component of an environmental impact report is outlined. Phase 1 involves the collection of base data; Phase 2 deals with analysis of energy use in the proposed project; and Phase 3 outlines a method for identifying problems and selected possible alternatives and mitigation measures (this selection procedure is summarized in the checklist at the end of the chapter). Finally, Phase 4 deals with the presentation of this information in the environmental impact report.

Phase 1 : Inventory

Table 2.1 is a summary of typical background information which may be needed for evaluating the energy impact of a proposed rezoning or general plan amendment. Due to the wide scope of projects included in this category, there often may be a need for specialized information not included in this summary. Also, the degree of detail for each item will vary from project to project. Typical sources of information are indicated in the table. It is advisable to obtain most of the required background information before proceeding with analysis of the data.

TABLE 2.1

BACKGROUND INFORMATION FOR PREPARING AN ENERGY EVALUATION

INFORMATION	DATA SOURCE																																												
<u>Acres</u> A. REGIONAL CONTEXT OF PROJECT 1. Residential land use (prepare separate analysis for each land use category). a. Total area (each category): _____ b. Area of proposed land use within 1/2 mile of neighborhood services and facilities: <table border="0" style="width: 100%;"> <thead> <tr> <th></th> <th style="text-align: center;"><u>Existing</u></th> <th style="text-align: center;"><u>Proposed</u></th> <th></th> </tr> </thead> <tbody> <tr> <td>Neighborhood park</td> <td style="text-align: center;">()</td> <td style="text-align: center;">()</td> <td>_____</td> </tr> <tr> <td>Elementary school</td> <td style="text-align: center;">()</td> <td style="text-align: center;">()</td> <td>_____</td> </tr> <tr> <td>Neighborhood shopping</td> <td style="text-align: center;">()</td> <td style="text-align: center;">()</td> <td>_____</td> </tr> <tr> <td>Mass transit stop</td> <td style="text-align: center;">()</td> <td style="text-align: center;">()</td> <td>_____</td> </tr> </tbody> </table> c. Area of proposed land use within 2 miles of community services and facilities: <table border="0" style="width: 100%;"> <thead> <tr> <th></th> <th style="text-align: center;"><u>Existing</u></th> <th style="text-align: center;"><u>Proposed</u></th> <th></th> </tr> </thead> <tbody> <tr> <td>Intermediate school</td> <td style="text-align: center;">()</td> <td style="text-align: center;">()</td> <td>_____</td> </tr> <tr> <td>High school</td> <td style="text-align: center;">()</td> <td style="text-align: center;">()</td> <td>_____</td> </tr> <tr> <td>Community center</td> <td style="text-align: center;">()</td> <td style="text-align: center;">()</td> <td>_____</td> </tr> <tr> <td>Community park</td> <td style="text-align: center;">()</td> <td style="text-align: center;">()</td> <td>_____</td> </tr> <tr> <td>Shopping center</td> <td style="text-align: center;">()</td> <td style="text-align: center;">()</td> <td>_____</td> </tr> </tbody> </table> d. Area of proposed development within 2 miles of major employment center: _____		<u>Existing</u>	<u>Proposed</u>		Neighborhood park	()	()	_____	Elementary school	()	()	_____	Neighborhood shopping	()	()	_____	Mass transit stop	()	()	_____		<u>Existing</u>	<u>Proposed</u>		Intermediate school	()	()	_____	High school	()	()	_____	Community center	()	()	_____	Community park	()	()	_____	Shopping center	()	()	_____	Area general plan or school district.
	<u>Existing</u>	<u>Proposed</u>																																											
Neighborhood park	()	()	_____																																										
Elementary school	()	()	_____																																										
Neighborhood shopping	()	()	_____																																										
Mass transit stop	()	()	_____																																										
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Community center	()	()	_____																																										
Community park	()	()	_____																																										
Shopping center	()	()	_____																																										
2. Commercial/office land use: total area _____ 3. Industrial land use: _____ a. Area with immediate access to rail freight service: _____ b. Area served by mass transit service (within 1/4 mile): _____	Area general plan.																																												

INFORMATION	DATA SOURCE
<u>Acres</u> 4. Recreational land use: total area _____ a. Convenient location with respect to residential development: () Yes () No	General plan or park district.
5. Public/semi-public land use: total area _____ a. Convenient locations of public facilities with respect to population served: () Yes () No	General plan.
6. All proposed development requiring urban services: total area _____ a. Area of proposed land use with adequate existing utility lines and plant: Water _____ Sewer _____ Electrical _____ Gas _____ Telephone _____ b. Area of proposed land use with special pumping requirements for utilities: Water _____ Sewage _____ c. Area of proposed land use served by existing streets: _____	Project proposal.
	Water district. Sanitary district. Utility company. Utility company. Telephone company.
	Water district. Sanitary district.
B. SITE CONDITIONS RELATED TO ENERGY USE 1. HYDROLOGY a. Existing defined drainage channels: Length designated as open space: _____ ft. Length designated for urban development: _____ ft. b. Existing water areas: _____ acres	Project proposal.

INFORMATION	DATA SOURCE
2. TOPOGRAPHY a. Percentage slopes in areas of proposed urban development: () 0-5% () 5-15% () 15% and over b. Predominant aspects of slopes in areas of proposed development: _____ _____	Project proposal or USGS map interpretation.
3. EXISTING NON-AGRICULTURAL VEGETATION a. Dense vegetation requiring clearance to accommodate proposed land use: _____ acres	Project proposal or aerial photos (Soil Conservation Service or other source).
4. EXISTING LAND USE a. Agriculture: acreages and average yields of each crop type: _____ _____ b. Other land use (describe): _____ _____	Current owner or County Extension Office.
5. SOILS AND GEOLOGY a. Prime agricultural soils (Classes I and II): _____ acres b. Site conditions requiring special engineering for structures: _____ acres	Soil Conservation Service. Geological reports on area; Seismic safety element of general plan.
C. CLIMATE CONDITIONS RELATED TO ENERGY USE 1. PREVAILING WINDS: a. Area of proposed development exposed to strong winter winds: _____ acres b. Area of proposed development with inadequate natural ventilation in summer: _____ acres	See climate discussion, Vol. 1

INFORMATION	DATA SOURCE
2. SOLAR INSOLATION () frequent fog () infrequent fog	
3. Heating degree days per year: _____ degree days	
4. Cooling degree days per year: _____ degree days	
D. PROJECT CHARACTERISTICS RELATED TO ENERGY USE <u>Acres</u> 1. Residential development (separate information for each category): a. Area designated for "planned development:" _____ b. Allowance for mixed commercial and residential development: () Yes () No 2. Commercial development: a. Area designated for "planned development:" _____ b. Area of compact shopping centers: _____ c. Area of "strip commercial" development: _____ 3. Industrial development: a. Area of planned industrial parks: _____	Area general plan or project proposal.
4. Summary of proposed energy conservation features of project.	Optional statement submitted with proposal.
E. PLANNING STANDARDS OR LEGAL RESTRICTIONS RELATED TO ENERGY USE <u>Existing</u> <u>Proposed</u> 1. Residential development: a. Maximum allowable density: _____ <u>units</u> / _____ <u>acre</u> _____ <u>units</u> / _____ <u>acre</u> b. Total possible number of residential units: _____ <u>units</u> _____ <u>units</u>	

INFORMATION	DATA SOURCE
c. Minimum lot size (rezoning): _____ sq.ft. d. Maximum height of structures (rezoning): _____ ft. e. Front yard setback (rezoning): _____ ft. f. Side yard setback (rezoning): _____ ft. g. Rear yard setback (rezoning): _____ ft. h. Envelope zoning included to protect owner's right to sunlight (rezoning): _____ i. Allowance of animal keeping for food (rezoning): _____ j. Allowance of on-site waste disposal systems (rezoning): _____ k. Lot coverage restrictions on unshaded paved surfaces: _____ l. Allowance for attached dwellings: _____ <u>Existing</u> <u>Proposed</u> _____ sq.ft. _____ sq.ft. _____ ft. _____ ft. _____ ft. _____ ft. _____ ft. _____ ft. _____ _____ _____ _____ _____	
2. Non-residential development: a. Maximum allowable gross square footage of interior space: _____ sq.ft. _____ sq.ft. b. Maximum height of structures: _____ ft. _____ ft. c. Lot coverage restrictions on unshaded paved surfaces: _____ d. Parking lot landscaping requirements: _____ e. "Envelope zoning" included to protect owner's right to sunlight: _____	General plan or zoning regulations.
F. ENERGY SOURCES 1. Existing on-site energy consumption, by fuel type. 2. Conventional energy sources, by type of fuel: description of peak load conditions and adequacy of supply.	Utility company, with permission of owner. Utility company.

Phase 2 : Analysis of Proposed Energy Use

Based on the information compiled in the Inventory phase, a clear picture should be drawn of the potential change in energy demand which would follow the proposed rezoning or general plan amendment. The analysis may include a comparison of the types of energy projected for use as well as the long-term availability of various types of energy.

Identification of energy impacts

All energy-consuming processes for future construction or other site alteration and operation of improvements should be identified. Table 1.11 is a summary of the types of initial and long-term energy impacts of a typical residential land use.

Calculation of energy impacts

A procedure for calculating total (direct and indirect) energy inputs for residential land use has been assembled and organized in a manner that gives the planner a step-by-step format for a relatively simple analysis, with the flexibility of exploring any of the various steps in greater detail and with increased accuracy.

The three steps are as follows:

- Step I Preparation of background data
- Step II Computations
- Step III Evaluation

In some cases it may not be possible to complete this evaluation because of time limitations or lack of base data. If this is the case, efforts can be concentrated on calculating selected energy inputs which may be of prime concern in the particular situation. In other cases it may happen that unusual circumstances or innovative design and planning approaches have led to sufficient diversity to defy the broad classifications used in the worksheets. There is sufficient detailed background data in this report for the analyst to track down the energy inputs of most proposed zoning actions.

Figure 1.8 will prove helpful in locating the more detailed sources of information found in the summary table of this section. For example, Table A.18 in Appendix A provides a method for breaking out the direct (fuel) costs for certain types of construction.

For non-residential land uses, estimates of total energy input may be prepared using Tables 1.1 and 1.7.

STEP I: PREPARATION OF BACKGROUND DATA

Table 2.2 may be used as a worksheet for simple analyses or as a guide for more detailed or complex analyses. Opposite each step in the preparation procedure is an indication of the source and format for the information required.

STEP II: COMPUTATIONS OF A 20-YEAR COMMITMENT FOR ENERGY CONSUMPTION

The data acquired in Step I may be used to complete the calculation worksheet (Table 2.3). For more complex or detailed analyses it may be useful to divide the study area into components and, following the same format, perform calculations for individual components. The sum of all the direct and indirect energy inputs from the right-hand columns would be the 20-year commitment for energy consumption.

STEP III: ANALYSIS OF LAND USE ALTERNATIVES

The energy impacts calculated in Steps I and II may be compared with those of alternate developments as well as continuation of the existing use using Tables 2.4 and 2.5 as a worksheet completed for each alternative.

By comparing energy utilization per residential unit, per person, and per unit geographical area, the analyst will have an overall understanding of the energy picture. For example, a land use with low energy input per acre might exhibit a high energy input per occupant or per residential unit.

Land areas that are rapidly occupied to their maximum density represent a better use of resources than if sparse development takes place with underused roads and utilities, because the energy required for both construction and maintenance is spread over more total users.

As an additional exercise, the analyst might wish to divide any of the figures in the right-hand column of Table 2.4 by 20 years to arrive at a yearly average energy input per year.

Comparison of existing and proposed energy use

In most cases, the study area will be used for agriculture. Table 2.5 provides a method of calculation to find direct energy inputs for various crops. For many energy-efficient crops, there will be a net output of energy from the site, although this is not always the case. Data for other energy-consuming activities on the site may be obtained from the utility company, with permission of the current owners. Since data is not available on indirect energy requirements for agriculture, an attempt could be made to separate out the direct inputs for the proposed urban land use, so that a direct comparison could be made between present and proposed conditions.

TABLE 2.2

STEP I
INFORMATION PREPARATION FORM
ENERGY INPUTS FOR RESIDENTIAL LAND USE

STEP	ITEM	OPERATION	REFERENCE	ENTER DATA
I.A.	Neighborhood development pattern.	Compare and select most applicable type from table.	Tables 1.3 and 1.4 and proposed zoning densities.	Check one: ☐ A. S.F. Conventional ☐ B. S.F. Clustered ☐ C. Townhouse ☐ D. Walk-Up ☐ E. High-Rise ☐ F. Housing Mix
I.B.	Quantity of residential units.	Select from table or compute maximum number of residential units allowed under projected densities.	Table 1.3 or maximum allowable densities under proposed zoning or land use category.	Enter number of units: A. Single Family B. Single Family C. Townhouse D. Walk-Up E. High-Rise
I.C.	Energy inputs per residential unit for street and utility infrastructure construction.	Select from table depending on development pattern type.	Table 1.5.	BTUx10⁵ BTU per linear foot of street
I.D.	Energy input per residential unit for construction.	Select from table depending on development pattern type.	Table 1.5.	BTUx10⁵ BTU energy input per residential unit for construction.

I.E. Build-out projection.

Predict time period
in which building
improvements will
reach allowed density
and select factor from
table.

Table 1.10.

Build-out factor.

I.F. Energy inputs per
residential unit for
operation and maintenance
of utility infrastructure
(20 years).

Select from table
depending on development
pattern type.

Table 1.5.

BTUx10⁵
BTU energy inputs per
residential unit for operation
and maintenance of utility
infrastructure.

I.G. Energy inputs for
residential building
operation (20 years).

Select from table
depending on location
and development
pattern type.

Table 1.6.

BTUx10⁵
BTU per residential unit.

TABLE 2.3

STEP II
CALCULATION WORKSHEET
20-YEAR ENERGY INPUTS FOR RESIDENTIAL LAND USE
(Direct and Indirect Inputs)

STEP

II.A.1	units Number of residential units (Table 2.2, Step I.B.).	x	BTUx10⁵ BTU's per residential unit for street and utility construction (Table 2.2, Step I.C.).	=	BTUx10⁵ Initial energy inputs for streets and utilities.		
II.B.1	units Number of units by type (Table 2.2, Step I.B.).	x	BTUx10⁵ Energy input per unit (Table 2.2, Step I.D.).	x	Proportion of units built after 20 years (100% = 1.0).	=	BTUx10⁵ Residential construction energy input.
II.B.2	units Number of units by type (Table 2.2, Step I.B.).	x	BTUx10⁵ Energy input per unit for operation and maintenance of utility infrastructure (Table 2.2, Step I.F.).	=	BTUx10⁵ Energy input for utility operation and maintenance.		
II.B.3	units Number of units by type (Table 2.2, Step I.B.).	x	BTUx10⁵ Energy input per unit for residential building operation (Table 2.2, Step I.G.).	x	Build-out factor (Table 2.2, Step I.G.).	=	BTUx10⁵ Energy input for residential operation.
II.B.4	Transportation energy inputs (optional: based on traffic analysis).					BTUx10⁵ Transportation energy input.	
II.C.1	TOTAL ENERGY INPUT OVER 20-YEAR PERIOD					=	BTUx10⁵

TABLE 2.4

ANALYSIS WORKSHEET FOR RESIDENTIAL DEVELOPMENT ALTERNATIVES

- A. TOTAL ENERGY INPUT OVER 20-YEAR PERIOD
(from Table 2.3, Step II.C.1)

BTUx10⁵

- B. TOTAL ENERGY INPUT PER BUILT UNIT

Total 20-year input
 (Item A, above).

÷

Estimated number
 of residential units
 built over 20-year
 period.

=

BTUx10⁵

- C. TOTAL ENERGY INPUT PER RESIDENT

Total 20-year input
 (Item A, above).

÷

Estimated number
 of residents after
 20-year period.

=

BTUx10⁵

- D. TOTAL ENERGY INPUT PER ACRE

Total 20-year input
 (Item A, above).

÷

Project area
 (gross acres).

=

BTUx10⁵

TABLE 2.5
CALCULATION OF EXISTING ENERGY INPUTS AND OUTPUTS ON SITE

A. EXISTING AGRICULTURAL ENERGY INPUT
(20-year period; continuing direct inputs for crop production).

	$1000 \frac{\text{kcal}}{\text{ton}}$	x		$\frac{\text{tons}}{\text{acre}}$	x		$\frac{.04 \text{BTU} \times 10^5}{1000 \text{ kcal}}$	x 20 yrs. =	
Fuel and electrical energy input. (Table 1.5).			Average crop yield.			Area of site in agricultural use.			$\text{BTU} \times 10^5$

B. OTHER EXISTING ENERGY INPUT ON SITE (projected over 20 years)

=

$\text{BTU} \times 10^5$

C. TOTAL EXISTING ENERGY INPUT ON SITE (A + B)

=

$\text{BTU} \times 10^5$

D. EXISTING AGRICULTURAL OUTPUT ON SITE (20-year period)

	$1000 \frac{\text{kcal}}{\text{ton}}$	x		$\frac{\text{tons}}{\text{acre}}$	x		$\frac{.04 \text{BTU} \times 10^5}{1000 \text{ kcal}}$	x 20 yrs. =	
Crop caloric content (Table 1.5).			Average crop yield.			Area of site in agricultural use.			$\text{BTU} \times 10^5$

E. NET EXISTING ENERGY INPUT ON SITE

-or-

NET EXISTING ENERGY OUTPUT ON SITE (D - C, if D is larger)

$\text{BTU} \times 10^5$

$\text{BTU} \times 10^5$

F. NET EXISTING INPUT PER GROSS ACRE

-or-

NET EXISTING OUTPUT PER GROSS ACRE

$\text{BTU} \times 10^5$

$\text{BTU} \times 10^5$

Phase 3: Identification of Problems, Mitigation Measures, and Alternatives

In the following paragraphs, basic energy conservation issues involving general plan amendments or rezonings are identified. These topics have been arranged in order of increasing detail, ranging from generalized regional considerations to the energy implications of specific zoning regulations. Thus, the final sections may not apply to general plan amendments.

In completing this phase, there is a basic problem in deciding when an increased use of energy is "wasteful." All urban development would involve increased consumption of energy, and there is a lack of standards for measuring energy efficiency of land use development patterns. However, relative judgments can be made, and any use of energy can be considered to be wasteful if it can be avoided through the use of a feasible alternative or mitigation measure.

Using the energy evaluation checklist.

To aid in determining which problems and possible mitigation measures or alternatives apply to a particular project, an energy evaluation checklist for proposed subdivision has been provided at the end of this chapter. To use the checklist, each energy conservation problem should be reviewed to see if it applies to the particular project under study. If so, one or more possible mitigation measures or alternatives to reduce the energy impact may be selected, based on the discussion in the text.

An alternative is considered to be a suggestion which would require extensive changes in the location or design of the project, while a mitigation measure is more of a "band-aid" action which can be adopted without major alterations to the project. However, there is no clear line between the two categories, and the classification in the checklist is only intended as a general guide.

There is, of course, a great deal of overlap among these problems and possible solutions. The cross reference column at the right of the checklist is provided to help in identifying these interrelationships, so that duplication of material can be kept to a minimum.

It should be noted that the alternative of "no project" is discussed separately at the end of the section.

A. REGIONAL CONTEXT OF PROJECT

The location of a land use within the region may have a major effect on energy consumption. In looking at the regional context of a rezoning or general plan amendment, the following energy-related issues should be considered:

(1) Dependence on the motor vehicle: Is the proposed land use conducive to use of mass transit, or will a dependence on the automobile be established? Are land uses mixed so that public facilities, parks and shopping areas are within walking or bicycling distance of residents? Is energy-efficient rail freight available for industrial areas?

(2) Construction and operation of utilities: Will the proposed land use changes lead to energy consumption for construction of treatment plants and utility lines? Will significant transmission line losses result from providing electrical service to the project location? If land uses will not have convenient linkages, or if major construction of utilities would be required to accommodate the proposed land uses, several mitigation measures or alternatives can be considered.

1. Contiguous urbanization: alternate project location.

In an energy-conserving community, new development takes place on land adjacent to existing built-up areas, with convenient access to community facilities. Intensity of land use decreases in an orderly pattern outward from the city core. However, there are obvious financial benefits to owners who

can obtain "leapfrog" general plan designations or rezonings for urban development in urban settings, far from existing developed areas. A land use decision to allow scattered pockets of urban land uses in rural or fringe areas can be a commitment to waste energy; subsequent development in these areas could aggravate the use of fuel for driving, as well as lead to extra energy input for construction of streets and utility lines.

If adequate land is available for the proposed land use, in a location more convenient to existing services and facilities, selection of an alternate location for the proposed land use may be advisable.

A-1 ALTERNATIVE: To avoid energy waste due to "leapfrog" development, another area closer to existing community services and facilities may be selected for the project.

APPLICABILITY: Proposed projects in locations remote from existing facilities or services.

CONFLICTS: Restrictions on individual use of land.

BENEFITS: Reduction in governmental costs for providing services; interim protection of open space; greater convenience for community residents.

2. Contiguous urbanization: timed development.

To reduce the energy problems of scattered development, the use of "timed development" zoning

or general plan designations may be used. Under this provision, a site may be planned for a particular land use, but the actual development on the site may be restricted until most suitable land closer to the city core has been developed.

A 2 **MITIGATION MEASURE:** To avoid energy waste due to scattered urban development in fringe areas, a "timed development" designation may be applied to the proposed rezoning or general plan designation, restricting the conversion of the area to urban use until land closer to the city core has been developed.

APPLICABILITY: Proposed rezonings or urban land use designations in locations remote from existing facilities or services.

CONFLICTS: Restriction on individual use of land. An overly-constrictive policy of contiguous development may also contribute to racial and economic segregation; some allowances for leaving patches of vacant land may be made so that all housing in a particular area is not of a uniform age.

BENEFITS: Reduction in governmental costs for providing services; interim protection of open space; greater convenience for community residents.

3. Convenient access to community facilities.

The location of schools, shopping centers, parks, and other community facilities within the overall land use pattern can also have an important effect on long-term fuel use. Traditionally, general plans and

zoning often sought to segregate various land uses. However, through careful planning, savings in energy may be achieved by mixing land uses so that travel distances are reduced.

a. Commercial land use.

In evaluating the location of commercial facilities to serve residential development, Table 2.6 may be used as a guideline, although it is recognized that local conditions may lead to considerable variation from these standards. Neighborhood shopping centers could be located within walking distance of residential development, and community shopping centers within bicycling distance of urban residential development can help to reduce automobile use. Regional shopping centers within four miles of urban residential areas also can help to keep automobile trip lengths to a minimum. Further energy savings could be obtained if all of these shopping areas would be served by mass transit.

A3a **MITIGATION MEASURE:** To reduce automobile use, shopping facilities should be conveniently located with respect to urban residential development. Neighborhood convenience shopping could be located within walking distance of all residential development. Additional energy savings could be realized if shopping areas would be served by mass transit.

APPLICABILITY: Rezonings and general plan amendments with potential for designation

TABLE 2.6
SUGGESTED STANDARDS FOR ENERGY-EFFICIENT LOCATION
OF SHOPPING FACILITIES

	NEIGHBORHOOD CENTER	COMMUNITY CENTER	REGIONAL CENTER
Radius of service area	1/2 mile	2 miles	4 miles
Minimum population to support	4,000	35,000	150,000
Site area (gross land area)	4-8 acres	10-30 acres	40-100+ acres
Desirable maximum size of center as a percentage of total area served	1.25% 1 acre/1000 pop.	1.00% 0.75 acre/1000 pop.	0.50% 0.67 acre/1000 pop.
Range of gross floor area	30,000- 75,000 sq. ft.	100,000- 250,000 sq. ft.	400,000- 1,000,000 sq. ft.
Number of stores and shops	5-20	15-40	40-80

SOURCE: Adapted from Urban Land, Vol. 20, No. 5, The Urban Land Institute.

TABLE 2.7

SUGGESTED STANDARDS FOR ENERGY-EFFICIENT LOCATION
OF RECREATIONAL FACILITIES

RECREATION FACILITY	RADIUS OF AREA SERVED
Playgrounds and Neighborhood parks	0.5 mile
Playfields	1.0 mile
Community parks	2.0 miles
Regional parks	10.0 miles

of commercial land uses.

CONFLICTS: Possible aesthetic objections to commercial development in residential neighborhoods.

BENEFITS: Potential increased convenience for area residents, and long-term energy savings.

b. Recreation areas.

By incorporating parks into areas of new residential development, automobile use to reach recreation areas may be significantly reduced. The policy of providing linear parks with pedestrian trails and bike paths can be particularly beneficial in encouraging the use of these alternatives to the automobile.

Table 2.7 provides some suggested standards for locating parks to minimize automobile travel. Again, these standards may vary, based on local conditions, but a basic goal of locating parks in close proximity to residential areas can be helpful in conserving energy.

A3b **MITIGATION MEASURE:** To reduce automobile use, all residential development could have convenient access to recreational areas. A policy of providing linear parks could encourage the use of bicycles and pedestrian paths as alternatives to the automobile.

APPLICABILITY: General plan amendments involving potential inclusion of recreational land use designations.

CONFLICTS: High costs for acquiring or maintaining park property.

BENEFITS: Potential for improved community appearance, more opportunities for exercise for resi-

dents, and possible long-term energy savings.

c. Schools.

If schools are located within walking distance, the use of fuel for school buses and private automobiles can be reduced. In Table 2.8 suggested standards for energy-efficient location of schools are indicated; again, variability in these standards would often be needed for local conditions.

A3c **MITIGATION MEASURE:** To reduce fuel consumption, schools could be located within walking distance of residential neighborhoods.

APPLICABILITY: General plan amendments with potential for designation of school sites.

CONFLICTS: Possible short-term financial problems for school districts, due to economics of centralized facilities.

BENEFITS: Increased convenience for students; potential long-term energy savings.

d. Other community services and facilities.

Medical clinics, government offices, and other community services and facilities are often in centralized locations, remote from residential neighborhoods. By planning for decentralized facilities, automobile use could be reduced.

A3d **MITIGATION MEASURE:** In planning for community facilities, potential fuel use could be reduced by adopting a policy of

TABLE 2.8

SUGGESTED STANDARDS FOR ENERGY-EFFICIENT LOCATION
OF SCHOOLS AND DAY-CARE CENTERS
(Assumed family size 3-5 persons)

	AREA REQUIRED	SIZE - NO. OF PUPILS	RADIUS OF AREA SERVED	NO. OF CHILDREN PER FAMILY	POPULATION SERVED	ASSUMED POPULATION CHARACTERISTICS
Day-care center/ nursery (2-1/2 - 5 yr. old)	4 class- 4000 sq.ft. 6 class- 6000 sq.ft. 8 class- 8000 sq.ft.	60 90 120	1-2 blocks desirable 1/8 mile maximum	.20	1,000 1,500 2,000	60 children of nursery school age per 1,000 persons
Elementary (5-11 yrs.)	Minimum- 7-8 acres Average- 12-14 acres Maximum- 16-18 acres	250 800 1,200	1/4 mile desirable 1/2 mile maximum	.54	1,500 5,000 7,000	175 children of elementary school age per 1,000 persons
Junior High (12-14 yrs.)	Minimum- 18-20 acres Average- 24-26 acres Maximum- 30-32 acres	800 1,200 1,600	1/2 mile desirable 3/4 mile maximum	.22	10,000 16,000 20,000	75 children of Junior High age per 1,000 persons
Senior High (15-18 yrs.)	Minimum- 32-34 acres Average- 40-42 acres Maximum- 48-50 acres	1,000 1,800 2,600	3/4 mile desirable 1 mile maximum	.22	14,000 24,000 34,000	75 children of Senior High age per 1,000 persons

SOURCE: Adapted from Planning Design Criteria, by Joseph De Chiara and Lee Koppelman, Van Nostrand and Reinhold Co., 1969.

decentralized government offices, medical clinics, and other facilities. Multiple use of public facilities could also reduce energy requirements for construction and operation of public buildings.

APPLICABILITY: Extensive general plan amendments.

CONFLICTS: Possible short-term economic disadvantages of decentralized facilities; potential decrease in quality of health care if services are fragmented.

BENEFITS: Potential increased convenience and sense of community for neighborhood residents.

e. Employment centers.

By providing dispersed industrial and office land uses in an urban area, some reduction in work commuting distances may be obtained. However, greater potential energy benefits may be obtained by planning major employment centers at locations accessible by mass transit.

A3e MITIGATION MEASURE: Industrial and office land uses could be dispersed throughout an urban area to reduce commuting distances to centralized employment centers.

APPLICABILITY: General plan amendments.

CONFLICTS: Decentralized employment centers may reduce the effectiveness of mass transit services.

BENEFITS: Potential reduction in commuting distances; reduced air pollution.

4. Land use location in relation to mass transit.

The energy benefits of mass transit in comparison to the automobile are well-known. In planning for new development, existing mass transit as well as the potential for service should be taken into account. It is particularly important to consider mass transit in planning large traffic generators such as shopping centers, high-density residential development, or major employment centers.

Mass transit service is virtually non-existent in many areas of Contra Costa County. However, the Bay Area Rapid Transit line, with its bus feeder routes, provides an important backbone for future expansion of mass transit in the county. Also, local bus service is provided to some unincorporated areas as well as cities in the Richmond area. High-density residential land use or other major traffic generators located within accessible range of these existing transit systems thus may provide energy savings in comparison with similar development not served by mass transit.

Even though there may be no existing rail or bus service in other areas, the potential for mass transit should be taken into consideration. In planning land uses the creation of "nodes" of clustered community facilities may later serve as a convenient transit stop. Rather than evenly-dispersed residential development, it may be advisable to plan for concentrated residential development at these nodes of activity.

A4 MITIGATION MEASURE: To increase the potential for using mass transit, high-density residential land uses or other major traffic generators could be located with convenient access to existing mass transit. Where transit service is not presently available, land-use planning of activity "nodes" for future service could be beneficial.

APPLICABILITY: Rezoning and general plan amendments involving residential development or other major traffic generators.

CONFLICTS: Possible community objections to high-density residential development in suburban areas.

BENEFITS: Potential long-term energy savings, as well as reduction of air pollution.

5. Land use location in relation to rail freight and waterways.

In comparison to trucking, shipping of freight by rail or water transport is more energy-efficient. In locating industrial land uses, consideration should be given to sites adjacent to railroads or navigable waterways.

A5 MITIGATION MEASURE: To increase the potential for energy-efficient shipping of freight by rail or barge, industrial uses could be located adjacent to railroads or navigable waterways.

APPLICABILITY: Industrial land use decisions.

CONFLICTS: Waterfront locations may also be desirable for recreational or residential use.

BENEFITS: Potential for long-term energy savings; possible lower cost to consumers for goods shipped by rail or barge.



B. LAND USE CONCEPT

At the time of rezoning or amendment of general plans, basic decisions are made about the characteristics of future land uses. From an energy conservation standpoint, several energy issues should be considered at this time:

(1) Are land uses grouped compactly within the study area? Would a proposed pattern of low-density, dispersed development lead to inefficient use of energy for construction and transportation:

(2) Can energy savings be achieved through policies or regulations calling for planned development of the study area? Would the proposed rezoning or general plan amendment lead to piecemeal development, with inherent energy inefficiency?

(3) Do proposed land use standards or regulations for development encourage or allow energy-efficient attached dwellings, regardless of density? Are the proposed general plan policies or zoning regulations geared to detached buildings?

Several interrelated suggestions can be made to achieve an energy-efficient land use pattern. These measures, discussed in the following paragraphs, may be advocated individually or together.

1. Planned development.

According to a federally-financed study of urban land use patterns, planned development of all densities is less costly to build and operate than equivalent unplanned development, in terms of environmental and economic costs, as well as energy consumption. For example, in 1973 a typical planned community development for 10,000 dwellings would have saved \$15.3 million (four percent) over "sprawl development" with the same housing mix. These cost savings would have been due to the elimination of costly road and utility connections between neighborhoods, and to more contiguous, compact development resulting from the emphasis on planning. Furthermore, planned development would save about six percent on operating costs (maintenance of utility lines, etc.), amounting to \$1 million in the tenth year of development. These dollar costs would represent an equivalent savings of indirect energy input. Direct energy consumption, because of reduced automobile travel, would be from 8 to 14 percent less in planned development than in unplanned developments.¹

Planned development refers simply to a coordinated approach to proposed property improvements, and may or may not include mixed land uses, clustering of development, or use of attached units. The benefits of mixing land use categories has been noted previously, and the following sections deal with clustering and attached units. It should be noted that the planned development approach is not limited to residential development; planned shopping centers, industrial parks, and office parks can provide the same energy and cost benefits.

Regulations for planned development zoning districts have been adopted as part of the Contra Costa County zoning ordinance. However, this "P-D" district has been applied only sparingly to zoning of land in the county.

B 1 ALTERNATIVE: In place of conventional development categories, general plan amendments and rezoning actions could specify a "planned development" approach.

APPLICABILITY: Land use study areas where property has not already been broken into small parcels, precluding a planned development approach.

CONFLICTS: Emphasis on planned development may lead to favoritism toward large property owners, as opposed to owners of small parcels.

BENEFITS: Substantial savings in energy consumption, construction costs, governmental expenses and personal costs for residents.

¹Real Estate Research Corporation, The Cost of Sprawl (Washington: U. S. Government Printing Office, 1974), pp. 7-15.

2. Clustering of development.

A frequent feature of planned development is flexibility in zoning regulations, allowing development to be clustered in favorable areas of the site. In place of conventional residential zoning, which leads to an even dispersal of uniform residential units, the cluster concept can lead to energy savings by reducing initial fuel input for street construction, shortening travel distances for motor vehicles, and making more open space available for bicycle trails and pedestrian paths. Cluster development is particularly advantageous when portions of a site have natural features (such as hilly terrain, dense vegetation, or natural streams) which would require extra energy input for development. Conservation benefits are greatest if attached units are used (see following section), but grouping of individual units also can provide significant energy savings.

In addition to residential development, the cluster concept may be appropriate to commercial or industrial land uses. The advantages of clustered commercial development are particularly stressed in *The Cost of Sprawl*. The study notes that, given a constant amount of floor space, shopping center commercial areas will be 20% less costly to build and service than a strip commercial area, with resultant energy benefits, a more attractive appearance, and fewer traffic accidents.¹

B 2 ALTERNATIVE: To reduce energy impact of construction and transportation, regulations or policies for clustering of land uses may be considered as an alternative to conventional land use planning which leads to even dispersal of development.

APPLICABILITY: All rezonings or general plan amendments where property has not already been broken down into small parcels.

CONFLICTS: Government officials and property owners may be reluctant to take on the responsibilities of working with flexible policies and restrictions of cluster development.

BENEFITS: Properly-designed residential cluster developments have general environmental benefits due to the increased areas of open space and reduced need for site alteration. Costs per unit for the developer usually are considerably less than for comparable non-clustered development. Clustered commercial development also has aesthetic and safety benefits in comparison with strip commercial development.

¹The Cost of Sprawl, p. 24.

3. Provision for attached units.

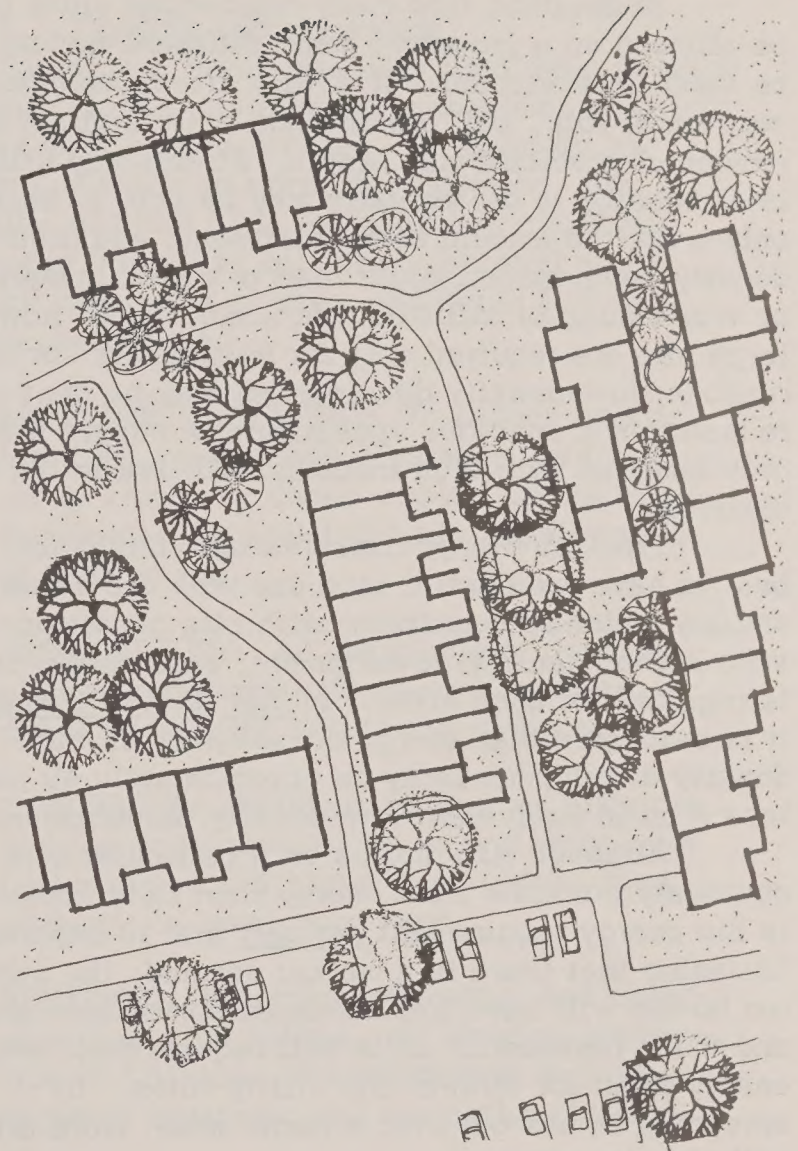
Attached buildings typically require considerably less energy for heating and cooling than equivalent detached units. While attached dwelling units have been associated with moderate-density or high-density development, provision for attached units can be made in low-density housing as well. Furthermore, policies and zoning regulations could encourage attached commercial buildings and other non-residential structures. "Zero lot line" regulations, allowing construction to the lot line under controlled conditions, can help in encouraging the use of attached units, as well as providing more efficient use of side yards for detached units.

B3 **MITIGATION MEASURE:** General plan policies and zoning regulations could encourage the development of energy-efficient attached residential units or non-residential buildings, regardless of density. "Zero lot line" regulations can be helpful in planning for attached units, in addition to their value for detached units.

APPLICABILITY: All general plan amendments or rezonings where detached residential units or nonresidential buildings are proposed.

CONFLICTS: Without adequate regulations for firewalls and acoustic insulation, attached units can lead to noise and safety problems.

BENEFITS: More energy-efficient land use patterns.



4. Higher-density residential development.

In deciding how many residential units should be allowed on a property, many different factors must be taken into account. If a hilly site is chopped into very small lots, soil erosion and other serious environmental problems may result. Streets and utility lines leading to the property may be able to handle only a limited amount of development, and high-density development might lead to traffic congestion or overloading of utilities. In some cases, however, large lots are required only for political or social reasons; low-density development may be desired to maintain a spacious appearance or ensure that only families with high incomes will live in the subdivision.

From an energy conservation standpoint, it is best to have residential land use with the maximum density which is consistent with site conditions. With higher-density development, less energy input is required for each home. In The Cost of Sprawl it is estimated that energy consumption in high-density development may be approximately 40 percent less than in equivalent low-density development.¹

Although fifty homes on a particular site will obviously consume more energy than forty homes, it is the energy requirement per unit that is important. Assuming that there is a market demand, the other ten homes will have to be located somewhere else, and these residential units will require their own energy input for streets and utility lines. By spreading homes out over a larger area, more driving will also be required.

Beyond a certain point, however, energy savings from higher-density development become less certain. If high-density development leads to coverage of the land with roofs and parking lots, the resulting heat build-up may increase energy demands for air conditioning in hot-summer areas (see page 126).

B4 ALTERNATIVE: Maximum residential densities consistent with site conditions could be designated in place of inefficient dispersed development.

APPLICABILITY: Rezoning and general plan amendments were site characteristics and services are adequate to serve higher densities.

CONFLICTS: If high-density development results in coverage of the land with roofs and pavement, heat build-up may increase energy demands for air-conditioning in hot-summer areas.

BENEFITS: Potential energy savings of 40% in comparison with low-density, dispersed development; less air pollution due to decreased travel distances per residential unit.

¹The Cost of Sprawl, p. 18.

C. RELATION OF LAND USE TO PHYSICAL CHARACTERISTICS

The physical characteristics of a planning area may have an important bearing on energy use of subsequent development. Initial energy inputs for grading and clearance can be affected by the topography and vegetation on the site. Land use policies for natural stream channels can influence energy requirements for flood control works and storm drainage. Consideration of microclimate in land-use planning can have an important long-term effect on future energy needs for heating and cooling of buildings; policies or regulations dealing with orientation of lots can also affect heating and cooling requirements. Land elevation can be a factor in determining whether or not energy might be required for pumping of water and sewage. Finally, the value of prime agricultural land for energy production should be kept in mind.

1. Grading and clearance.

Location of high-intensity land uses in areas of steep slopes can aggravate problems of energy use as well as soil erosion. In addition to grading of roads to serve development, the creation of level pads for buildings could add to energy input. In densely-vegetated areas fuel for clearance of trees and brush may also add to energy use.

C1 MITIGATION MEASURE: To reduce energy input for grading and clearance, areas of steep slopes or dense vegetation could be designated for low-intensity development or open space.

APPLICABILITY: All rezonings or general plan amendments with steep slopes or dense vegetation within the study area.

CONFLICTS: Residential uses on hillsides or in heavily-wooded areas typically have better views and higher land values than property on level open land.

BENEFITS: Reduction of grading and clearance may also reduce soil erosion; protection of hillsides and woodlands may have regional aesthetic and recreational value.

2. Storm Drainage.

On most undeveloped areas, rainwater is absorbed by the soil or is taken off the site in natural drainage channels. However, urban development greatly increases the amount of runoff from the area. A considerable input of energy is typically needed for construction of storm sewers and channels to avoid flood problems.

In many cases, existing natural drainage channels may still be adequate to handle most of this runoff. However, these streams may follow irregular routes, and some periodic flooding may occur along the banks; as a result stream courses in urban areas are often channelized.

As an alternative approach, land use policies can call for adequate open space to be left along stream banks. In addition to reducing energy needs for storm drainage improvements, this open space can provide recreational and other environmental benefits.

C2 MITIGATION MEASURE: Initial energy input for construction of storm drainage facilities may be reduced by open space corridors along natural drainage channels.

APPLICABILITY: Study areas with existing defined drainage channels.

CONFLICTS: Maintenance costs and related energy requirements may be increased if natural drainage channels are used.

BENEFITS: Potential recreational, aesthetic and other environmental benefits of natural stream courses, in addition to possible energy savings.

3. Adaptation to microclimate.

In evaluating a rezoning or general plan amendment, consideration should be given to the differences in climate which exist within the study area. These local variations may have a significant effect on long-term energy use for home heating and cooling.

The aspect of a slope, or the direction it is facing, affects the amount of sunlight reaching the homesite. In Contra Costa County, a south-facing slope generally has the most potential for energy-conserving development. This slope aspect increases the feasibility for using solar energy in space heating and water heating; in addition, less fuel generally would be needed for heating in winter. In comparison with south slopes, development on north slopes generally would require the most fuel for heating.

In addition to slope aspect, the location of development in relation to prevailing winds should be evaluated. Avoidance of cold winter winds, as well as access to welcome summer breezes, may be important. Exposed ridges and gaps with strong winter winds will add to heating fuel needs for development in these locations. However, a sheltered location in hot-summer portions of the county may increase the need for air conditioning, aggravating peak-load demand for electricity.

C3

MITIGATION MEASURE: Long-term energy use for home heating and cooling may be reduced by locating development in favorable microclimatic areas of the study area, including:

- a. South-facing slopes; avoidance of north-facing slopes;
- b. Areas protected from cold winter winds; avoidance of exposed ridge-tops and wind gaps;
- c. Locations with access to summer breezes; avoiding overly-sheltered locations in hot-summer areas of the county.

APPLICABILITY: Rezoning or general plan amendments with development proposed in areas of unfavorable solar or wind conditions.

CONFLICTS: Planning for microclimate benefits alone may conflict with other energy and environmental needs; a comprehensive review of all site and environmental conditions is needed.

BENEFITS: In addition to potential energy savings, comfort of residents and users may be improved by avoiding areas with strong winds or unfavorable sunlight conditions.

4. Planning for energy-conserving building orientation.

The orientation of buildings can have a considerable effect on fuel used in cooling or heating. Studies in Davis, California, have shown that maximum south windows exposure, with proper shading devices, can achieve significant energy savings in that community. Similar benefits could be obtained in all Contra Costa County climate conditions, particularly in hot-summer areas.

While this need for proper orientation of buildings is discussed in more detail in Chapter 4, general plan policies can encourage the use of energy-conserving orientation in new development. Policies dealing with subdivision lot layout, as well as building orientation, can provide a basis for energy conservation in new development. In particular, the use of streets running in east-west directions should be encouraged, since buildings facing these streets would have greater opportunity for an energy-conserving window orientation to the south (see Chapter 3, p. 116). Zoning ordinances could provide certain incentives to achieve these benefits.

C4 MITIGATION MEASURE: To plan for energy-conserving orientation of future urban development, general plan policies could encourage the use of streets running in east-west directions, and lots oriented on a north-south axis, to provide greater opportunity for south orientation of windows in buildings.

APPLICABILITY: All general plan amendments and rezonings.

CONFLICTS: Possible monotony of development and restriction on individual freedom if inflexible zoning regulations would be applied.

BENEFITS: Potential long-term energy conservation and cost savings to residents.

5. Elevation of development in relation to utilities.

In a water system, pressure decreases with increasing elevation. Above a certain height, supplementary pumping of water may be necessary to serve urban development above this level. In addition to the electricity requirement for pumping, energy input may be needed for construction of additional storage tanks or reservoirs, and for maintenance of pumps and tanks.

Supplementary input may also be needed for sewage systems, which operate on gravity flow. If urban development would be located below the elevation of trunk sewer lines serving the area, electricity will be needed for pumping sewage up to the line. By avoiding development in areas where special pumping would be required, energy can be conserved.

C5 MITIGATION MEASURE: To reduce electrical energy use for pumping, and to avoid additional energy input for construction and maintenance, urban development in locations requiring supplementary pumping of water or sewage may be relocated or eliminated.

APPLICABILITY: Rezoning or general plan amendments with proposed development above critical elevations for water pressure, or below critical elevations for gravity flow of sewage.

CONFLICTS: Possible economic loss to land owner.

BENEFITS: Energy savings and elimination of possible "problem spots" in water and sewer systems; greater reliability of service in case of power failure.

6. Loss of agricultural productivity.

Urban land uses generally consume rather than produce energy. However, energy requirements for agricultural land often are balanced by useful energy outputs in the form of food. In particular, prime agricultural land has the capability for intensive energy production. Highest energy efficiencies are often obtained on non-prime land used for dry-farming, however.

C 6 MITIGATION MEASURE: To preserve existing agricultural energy production, urban development should be shifted away from good or prime agricultural land.

APPLICABILITY: Projects with prime agricultural soils or existing energy-efficient agricultural use.

CONFLICTS: Possible need for urban expansion on agricultural land.

BENEFITS: Protection of open space and existing economic base.

D. CIRCULATION WITHIN THE STUDY AREA

In addition to regional energy issues related to site location, described in Section A, the layout of circulation routes within the study area can have an important effect on energy use. An energy-conserving circulation system within the study area can reduce initial energy input for construction, as well as diminish long-term vehicular fuel consumption.

1. Length of circulation routes.

As noted previously, initial energy input for urban development is closely related to the total length of streets. Any measure to reduce the amount of streets, while still providing satisfactory circulation, is an important way to conserve energy. This advantage can be cancelled out, however, if long, circuitous routes are needed to provide access; direct traffic patterns are needed.

When used properly, a policy advocating the use of cul-de-sacs can provide a basis for reducing street lengths in future development. In place of a pattern where all streets are continuous, cul-de-sacs can feed traffic onto collector streets. The lack of through-traffic on cul-de-sacs also makes these streets safer for children.

An estimate of the energy benefits obtained by reducing street lengths can be calculated, using the information in Table 1.5.

D1 MITIGATION MEASURE: To reduce construction energy input and long-term fuel use for vehicles, a policy of using the minimum length of streets needed to provide satisfactory circulation may be adopted.

APPLICABILITY: General plan amendments.

CONFLICTS: Unless circulation patterns are carefully considered, the short-term energy advantages of minimum street lengths could be cancelled out by long-term energy waste due to excessive driving. Convenience for residents could also be hampered by awkward street patterns where minimum length is the only criterion.

BENEFITS: Minimum street lengths provide an obvious financial benefit to developers, which can be passed on to the homebuyer. The extra space created by eliminating excessive streets can be used for recreation.

2. Favorable traffic flow conditions.

In keeping street lengths to a minimum, the need for convenient traffic circulation must be kept in mind. General plans should encourage circulation systems designed to keep travel distances to a reasonable minimum. The collector streets should also route traffic in the direction of most traffic generators.

D2 MITIGATION MEASURE: To avoid long-term energy waste due to unfavorable traffic flow patterns, a policy of providing favorable traffic flow conditions may be included in general plan amendments. In keeping with this policy, circulation routes designated in general plans may be realized to provide more favorable traffic flow.

APPLICABILITY: General plan amendments including circulation policies or route designations.

CONFLICTS: This measure may conflict with the previously-stated need to keep street lengths to a minimum.

BENEFITS: Potential long-term fuel savings, and increased convenience for residents.

3. Street widths.

Standards for width of streets are frequently established as general plan policies to provide a basis for specific regulations in the subdivision ordinance. These policies are based on the need for smooth traffic flow, as well as for emergency access requirements. In some cases, however, these needs may be satisfied by narrower streets than those established under current policies. In particular, cul-de-sacs and other local streets could be reduced to a width of 26 feet or less, if adequate regulation of parking would be maintained. In addition to minimizing energy input for paving, these reduced street widths could reduce the problem of heat build-up in hot-summer areas.

D3 MITIGATION MEASURE: General plan standards for street widths could be modified to reduce initial energy input for paving, as well as long-term effects due to summer heat build-up on pavement.

APPLICABILITY: General plan amendments involving street width policies.

CONFLICTS: Possible increased traffic hazards or inconvenience on narrow streets.

BENEFITS: Cost savings in urban development.

4. Non-motorized circulation.

In reducing the dependence on the private automobile for travel, new development can be planned to encourage walking and bicycling. General plan policies and route designations for regional networks of pedestrian trails and bicycle routes may be instrumental in reducing long-term fuel consumption, as well as providing health and recreational benefits. A general plan policy of requiring sidewalks in all areas of urban development can also help in the encouragement of non-motorized circulation. (A more detailed discussion of bicycle and pedestrian circulation is included in Chapter 3.)

D4 MITIGATION MEASURE: To reduce long-term fuel consumption, general plans could establish policies and route designations for regional networks of pedestrian trails and bicycle routes; a policy of requiring sidewalks in all areas of urban development could also contribute to long-term energy benefits.

APPLICABILITY: General plan amendments involving transportation policy and route designation.

CONFLICTS: Potential safety hazards of incomplete or improperly-planned bicycle networks; additional cost of sidewalks.

BENEFITS: Possible long-term energy savings, as well as health and recreational benefits.

E. DETAILED POLICIES AND REGULATIONS FOR URBAN DEVELOPMENT

A number of additional policies or regulations concerning details of urban development can provide energy conservation benefits. Because of the more precise nature of these measures, they have been included in Sections E and F of Chapter 3. The importance of these suggestions, particularly in an evaluation of a detailed rezoning proposal, should not be overlooked. In particular, policies and regulations dealing with alternative energy sources should be considered when evaluating rezoning proposals or general plan amendments.

F. SUMMARY

After reviewing the various mitigation measures and alternatives to reduce the long-term energy consumption of the project, it may be that serious and unavoidable adverse energy impact would still result from approval of the subdivision. The question of need for the project should be carefully considered; intensive demand for housing could lead to later approval of a subdivision with much higher energy input per unit. In discussing the "no project" alternative, the comparison of existing and proposed energy use (see page 31) should be noted; even if the project were denied, substantial energy use on the site might continue in some cases.

F1 ALTERNATIVE: No project.

APPLICABILITY: All projects.

CONFLICTS: Possible contribution to housing shortages.

BENEFITS: Long-term energy savings.

Phase 4: Presentation of Information

There are various ways to prepare the energy component of an environmental impact report for a project, and the following procedure is only one possible method. The basic rule to remember is that all information presented in the report should have a practical purpose: to describe the energy impact of the project, and to outline methods of improving the situation. A sample outline of an energy component (page 64) has been included as a guide for the general format of the report. However, the state guidelines for preparation of the energy component also should be consulted to be sure that all necessary information has been included.

A. Introduction to the report.

A brief explanation of the basic purpose of the energy component should be included, noting the total scope of energy usage to be covered in the report. The concept of indirect inputs, based on the science of energetics, should be discussed, and the importance of considering initial as well as long-term inputs should be noted. A standard paragraph introduction could be prepared for use in all similar EIR's, including a statement of the legal basis for the energy component in California law.

B. Background information.

It is important to be selective in presenting only the background information which is absolutely necessary in making an evaluation of energy use. Most of the necessary data will have been compiled and presented in other sections of the EIR, and this material should be incorporated in the energy component by reference only.

1. Project description. A brief summary should be made of the following project characteristics related to energy use:

a. Identification of energy-consuming processes for initial construction and long-term operation. (This general description would be followed by a more detailed breakdown of energy input in the section on energy impact.)

b. Energy conservation measures (if any) which have been proposed by the proponent of the project.

c. Key project characteristics which will have a direct influence on energy use.

d. Compliance of the project with existing energy standards. (Applicable only if specialized energy standards applicable to the project have been established.)

2. Environmental setting. This section should include a brief summary of the following information:

a. Inventory of existing energy sources by fuel type.

b. Inventory of existing on-site energy use (in most cases, the energy input for agricultural uses).

c. Site and climate conditions which have a direct bearing on energy impact.

C. Energy impact of project.

The basic purposes of this section should be to present a clear picture of initial and long-term energy use, and to provide a framework on which to base possible mitigation measures and alternatives for conserving energy. Energy impacts should be described in a "life-cycle" context, including construction, operation and maintenance; types of fuel should be identified.

1. Identification and calculation of impacts. The potential energy demands which apply to the particular project should be selected from Table 1.11. In calculating these impacts, the complete procedure for predicting energy use (outlined earlier in the chapter) may be followed. However, it may be sufficient to concentrate on one or more aspects of energy use which are important considerations for a particular project.

Comparisons with other projects (in terms of energy use per residential unit) would be helpful, once a number of EIR's have been prepared following this procedure.

2. Effects on energy sources. The long-term impact on local and regional energy supplies should be noted. Particular attention should be focused on critical issues such as peak hourly or seasonal demands for fuel.

3. Comparison of existing and proposed energy use on site. The existing on-site energy use should be compared with the long-term energy consumption of the project, and the effect that the change in energy consumption patterns will have on available supplies of fuel.

D. Mitigation measures and alternatives.

These sections should receive the greatest emphasis in the energy component of the EIR. The energy conservation checklist and text should be used to select those mitigation measures and project alternatives which apply to the project. After identifying a problem of wasteful or avoidable energy consumption, each suggestion for improvement should be clearly set off from the general text by underlining or other techniques. Trade-offs and constraints for each suggestion should be noted, and it should be identified as a mitigation measure or alternative. Mitigation measures

or alternatives described elsewhere in the EIR (for soil conservation, etc.) should be evaluated in terms of their effect on energy use.

Since the distinction between mitigation measures and alternatives is often artificial, they have been combined in the format of this report. However, it may be advantageous to include a separate summary of project alternatives as well as alternative energy sources which have been noted in the report.

E. Unavoidable adverse impacts.

Following the review of possible alternatives and mitigation measures which could reduce or eliminate impacts, a summary should be made of the remaining unavoidable net energy demands.

F. Irreversible commitment of energy resources.

No irreversible commitment of resources would be involved in a rezoning or general plan amendment. (The use of non-renewable energy sources for initial subdivision improvements would be an irreversible commitment of resources. However, many of the long-term energy impacts may not fall in this category, since the potential exists for switching from fossil fuels to renewable energy sources, such as the use of solar energy for heating.)

G. Short-term gains versus long-term benefits.

Initial cost-cutting on site improvements could save energy initially, but this short-term benefit could be cancelled out. (For example, eliminating sidewalks could reduce initial energy input, but this gain could be cancelled out by greater long-term dependence on the automobile.) Examples of this type should be noted.

H. Growth inducement as related to energy use.

The growth-inducing impact of project approval can be related to long-term energy implications by briefly summarizing the calculations of impact in Phase 2.

I. Summary of critical issues.

The most significant energy impacts, and the most effective means of reducing energy demand, could be summarized at the end of the report. Measures which could save money, as well as provide energy savings, could be particularly emphasized.

TABLE 2.9

SAMPLE OUTLINE

ENERGY COMPONENT OF AN E.I.R.

- A. Introduction
 - 1. Characteristics of energy use (general concepts)
 - a. Direct and indirect inputs
 - b. Initial and long-term inputs
 - 2. Purpose and legal basis of E.I.R. energy component
- B. Background information
 - 1. Project description
 - a. Identification of energy-consuming processes
 - b. Proposed energy conservation measures
 - c. Project characteristics with direct influence on energy use
 - d. Compliance of project with existing energy standards (if any)
 - 2. Environmental setting
 - a. Existing energy sources by fuel type
 - b. Existing on-site energy use
 - c. Site and climate conditions related to energy use
- C. Energy impact of project
 - 1. Identification and calculation of impacts
 - 2. Effects on energy sources
 - 3. Comparison of existing and proposed energy use on site
- D. Mitigation measures and alternatives (may be separate headings)
- E. Unavoidable adverse impacts
- F. Irreversible commitment of energy resources
- G. Short-term gains versus long-term benefits
- H. Growth inducement as related to energy use
- I. Summary of critical issues (optional)

ENERGY EVALUATION CHECKLIST:
REZONINGS AND GENERAL PLAN AMENDMENTS

ENERGY CONSERVATION PROBLEM	MANUAL PAGE	POSSIBLE MITIGATION MEASURE (M) OR ALTERNATIVE (A)	A	M	CROSS- REFERENCE
A. <u>REGIONAL CONTEXT OF PROJECT</u>					
Proposed land uses remote from services and facilities may result in excessive fuel consumption for access to site, for utility line construction, in addition to transmission line loss for utilities.	38	A-1. Choose alternate site with convenient access to services and facilities.	A		F-1.
	39	A-2. Use "timed development" zoning or general plan designation.		M	
	39	A-3. Provide convenient access to community facilities:		M	
		a. Shopping facilities conveniently located with respect to residential development; neighborhood shopping facilities within walking distance of residential development.			
		b. Recreational facilities located to minimize auto travel, with an emphasis on linear parks.			
		c. Schools within walking distance of neighborhoods served.			
		d. Decentralize other community services and facilities.			
		e. Employment centers close to residential neighborhoods.			
	45	A-4. Provide mass transit or plan land use patterns to encourage future use.		M	
	45	A-5. Locate industrial uses with access to railroads or navigable waterways.		M	
B. <u>LAND USE CONCEPT</u>					
Conventional urban development may not be energy-efficient due to dependence on the automobile in dispersed low-density development, inefficient layout of streets and utilities, and use of inefficient detached buildings.	47	B-1. Use a "planned development" approach.	A		B-2,3,4; F-1.
	48	B-2. Clustering of residential or nonresidential development.	A		B-1; C-1,2,3,4,5.
	49	B-3. Plan for use of attached units.		M	B-1; D-1,2; F-1.
	50	B-4. Higher-density development.	A		B-1.

ENERGY CONSERVATION PROBLEM	MANUAL PAGE	POSSIBLE MITIGATION MEASURE (M) OR ALTERNATIVE (A)	A M	CROSS- REFERENCE
<u>C. RELATION OF LAND USE TO PHYSICAL CHARACTERISTICS</u>				
1. GRADING AND CLEARANCE Avoidable operation of equipment for grading or clearance in areas of steep slopes or dense vegetation.	51	C-1. Designate areas of steep slopes or dense vegetation as open space or low-density development.	A	A-1; B-2; F-1.
2. STORM DRAINAGE Avoidable operation of equipment and use of energy-intensive materials for stream channelization and other storm drainage improvements.	52	C-2. Designate natural drainage channels as open space corridors.	M	B-2; D-1.
3. ADAPTATION TO EXISTING MICROCLIMATE Inefficient home heating/cooling due to development located in unfavorable microclimatic areas.	53	C-3. Relocate development in more favorable microclimatic areas: a. south-facing slopes; b. areas protected from winter winds; c. locations with access to summer breezes.	M	A-1; B-1,2; F-1.
4. PLANNING FOR ENERGY-CONSERVING BUILDING ORIENTATION Inefficient home heating/cooling due to east-west building orientation.	54	C-4. Adopt general plan policies for energy-conserving orientation.	M	B-1,2.
5. ELEVATION OF DEVELOPMENT IN RELATION TO UTILITIES Supplementary electricity for pumping of water and sewage may be required for some development.	55	C-5. Eliminate or relocate areas of proposed development requiring special pumping for water and sewage.	M	A-1; B-1,2; F-1.
6. LOSS OF AGRICULTURAL PRODUCTIVITY Conversion of site to urban development may result in loss of food energy output from site.	56	C-6. Designate agricultural areas as open space.	M	F-1.

ENERGY CONSERVATION PROBLEM	MANUAL PAGE	POSSIBLE MITIGATION MEASURE (M) OR ALTERNATIVE (A)	A M	CROSS- REFERENCE
D. <u>CIRCULATION WITHIN THE STUDY AREA</u>				
1. LENGTH OF CIRCULATION ROUTES Avoidable energy use for construction of streets and utilities, due to inefficient circulation system layout.	57	D-1. Reduce lengths of circulation routes.	M	A-1; B-1,2; D-2.
2. TRAFFIC FLOW Inefficient automobile use due to unfavorable traffic flow.	58	D-2. Redesign circulation system to provide more favorable traffic flow.	M	B-1,2; C-4; D-1.
3. STREET WIDTHS Avoidable construction energy input, and possible impact from summer heat build-up, due to street widths in excess of traffic needs.	58	D-3. Reduce street width standards.	M	
4. NON-MOTORIZED CIRCULATION Dependence on motorized transit due to lack of alternatives.	59	D-4. Establish policies and route designations for regional pedestrian trails and bicycle routes.	M	A-2; B-1.
E. <u>DETAILED POLICIES AND REGULATIONS FOR URBAN DEVELOPMENT</u>				
	60	E. See Chapter 3, sections E and F.		
F. <u>SUMMARY</u>				
Serious and avoidable adverse energy impact would result from project.	61	F-1. No project.	A	A-1; B-1,2; C-1,3,5.

CHAPTER 2: CASE STUDY

ENERGY COMPONENT OF
ENVIRONMENTAL IMPACT REPORT

SAN RAMON GENERAL PLAN AMENDMENT

INTRODUCTION

In recognition of the need to plan for energy-conserving development, the State of California requires that new projects be evaluated to determine their effect on energy resources, with an identification of ways to reduce wasteful consumption of fossil fuels. This report is intended to meet this requirement, within the guidelines for E.I.R. preparation established by the State government.

In evaluating the energy impact of this general plan amendment, it is important to keep the total energy picture in mind. In this study, a "total energy input" approach is used, incorporating direct as well as indirect energy inputs. Direct energy inputs refer to fuels actually consumed at the point of use, such as the quantity of fuel used in heating a home. Indirect or hidden energy inputs include the energy which is "built into" the product before the point of use, such as the fuel consumed in mining coal or manufacturing a light pole.

A general plan does not lead immediately to actual construction, but basic commitments to allocate energy resources are adopted at the time of plan adoption. These energy commitments need to be viewed in a long-term context, with the understanding that a certain pattern of urban development may lock in a dependence on energy use, whether for home heating or for use of automobiles to reach dispersed areas of housing. Also, agricultural land may be used for producing energy, in the form of food, and the loss of this energy production should also be taken into account.

FIGURE 2.10
LOCATION OF STUDY AREA
SAN RAMON VALLEY AREA GENERAL PLAN
Concord



TABLE 2.11

EXISTING AND PROPOSED GENERAL PLAN LAND USE
DESIGNATIONS AND ACTUAL 1970 LAND USE

General Plan Land Use	Adopted Composite Plan			Proposed Plan			Existing Land Use in 1970 of Area*		Change from Adopted to Proposed Plan	
	by Sub- Category	by General Category	%	by Sub- Category	by General Category	%	Acreage	% of Total	Acres	% of Area
RESIDENTIAL		27,164	37.9		16,357	22.8	3,958	5.5	-10,807	-15.1
Single Family		(26,432)	(36.9)		(15,691)	(21.9)			(-10,741)	(-15.0)
Low Density Expansion	2,022			0						
Country Estate	0			2,403						
Low Density	19,637			9,825						
Medium Density	3,741			2,592						
High Density	1,032			871						
Multiple Family	732	(732)	(1.0)		(666)	(.9)			(-66)	(-.1)
Very Low Density	--			293						
Low Density	--			64						
Medium Density	--			309						
SERVICE AND EMPLOYMENT		1,948	2.7		1,576	2.2	303	.3	-372	-.5
Overall Commercial		(768)	(1.05)		(738)	(1.3)	192	0.2	(-30)	(+.15)
Commercial	413			480						
Office	295			258						
Commercial Service	60									
Highway										
Controlled Industry	1,180	(1,180)	(1.65)	838	(838)	(.9)	111	0.1	(-342)	(-.65)
PUBLIC AND SEMI- PUBLIC	150	150	.2	541	541	.7	390	0.5	+391	+.5
OPEN SPACE		42,249	59.0		53,037	74.1	65,375	91.1	+10,788	+15.1
Parks and Recreation				5,313						
Agricultural Open Space				10,221						
Agricultural Preserve				5,313						
Other							1,730	2.4		
TOTALS		71,511	99.7		71,511	99.8	71,756	100.0	same	same

*The General Planning Area acreage and boundaries in 1970 differed slightly from the present planning area. Data from Contra Costa County Planning Staff graphics preimeter estimates and 1970 U. S. Census.

PROJECT CHARACTERISTICS RELATED TO ENERGY USE

In Table 2.11, the basic land uses in the proposed general plan are summarized. Based on the general plan, about 12,000 acres of the study area which were open space in 1970 would be converted to urban development.

Specific project characteristics influencing energy use are listed below.

(a) Location of community services and facilities, employment centers, mass transit lines, and rail freight service, influencing fuel use for transportation.

(b) The density and dispersion of residential and nonresidential development, influencing dependence on the automobile; energy requirements for construction of site improvements, and the fuel needs for heating and cooling of detached buildings.

(c) Topography and vegetation in areas of proposed urban development, influencing energy use for grading and clearance.

(d) Land use designations for stream channels, influencing energy needed for construction of artificial flood control improvements.

(e) Consideration of microclimate in relation to land use, as well as policies regarding lot

orientation in subdivisions, which would influence heating and cooling requirements for homes.

(f) Elevation of proposed development in relation to water supply and sanitary sewage facilities, which could influence electricity use for pumping.

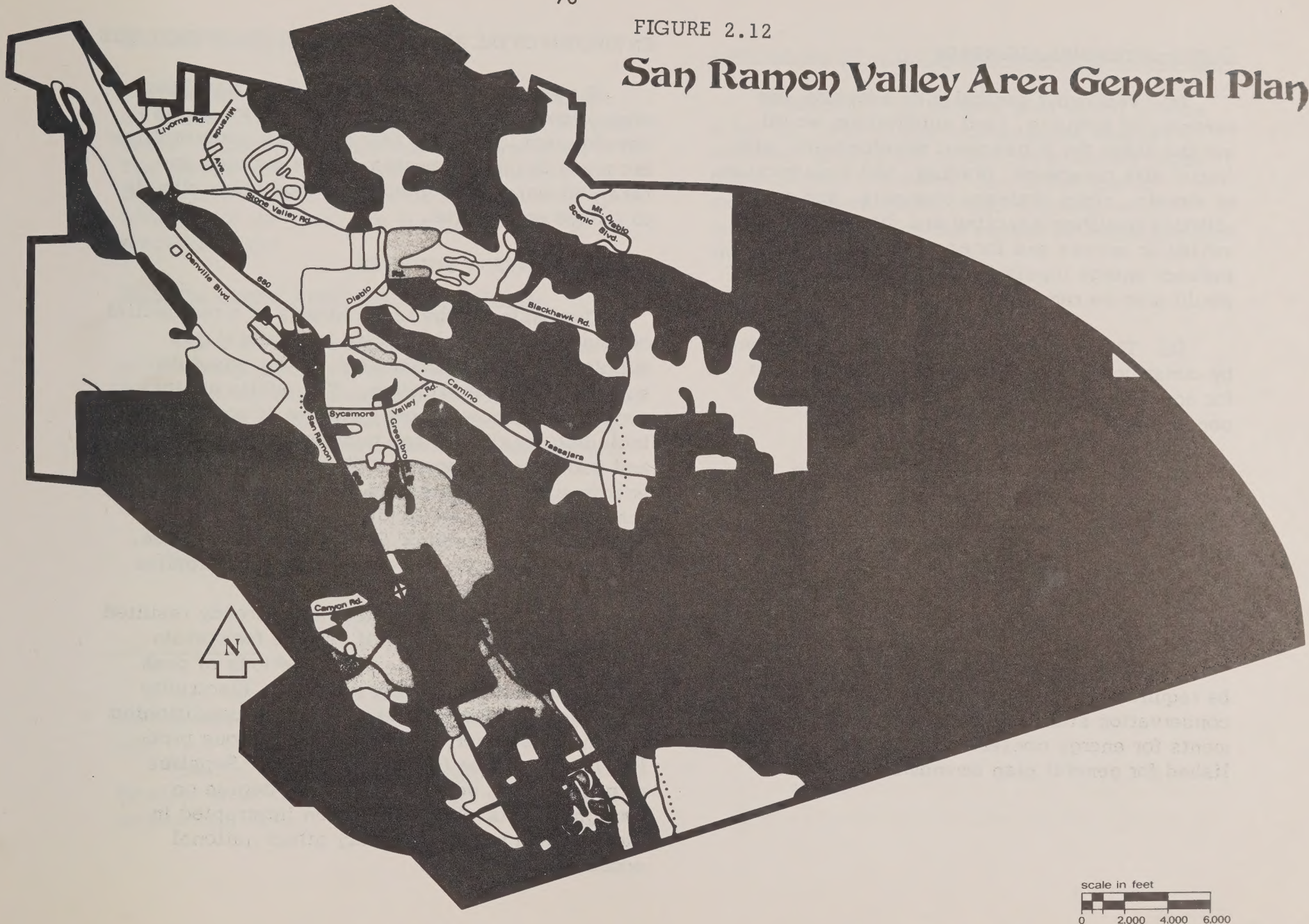
(g) Internal circulation within the study area, influencing initial construction inputs as well as long-term fuel use.

(h) Provision of walking and bicycling routes as alternatives to automobile use.

These key project characteristics, as well as other minor factors influencing energy use, will be discussed in more detail in the section on mitigation measures and alternatives.

FIGURE 2.12

San Ramon Valley Area General Plan



Energy-consuming processes

(a) Following general plan adoption and rezoning of property, land subdivision would set the stage for subsequent development, with initial site clearance, grading, and construction of streets, storm drainage channels, and other utilities requiring gasoline and diesel oil for vehicular access and for operation of equipment. Indirect energy inputs for fuel and materials would also be required.

(b) The creation of lots would be followed by construction of buildings with energy input for access to the site and for operation of construction equipment.

(c) Long-term energy input would be required for operation of buildings including fuel for heating and cooling, electricity for lighting and power, and motor fuel for transportation within the study area.

Energy conservation standards

Future development in the study area would be required to meet established state energy conservation standards, but no specific requirements for energy conservation have been established for general plan amendments.

ENVIRONMENTAL SETTING RELATED TO ENERGY USE

The relatively mild climate of the San Ramon area offers the potential for energy-conserving development, provided that maximum opportunities are made to use renewable energy sources and taken advantage of methods for modifying climate to reduce energy use.

EXISTING ENERGY SOURCES

The basic energy requirements of a residential community are for electricity and natural gas supplied by the public utility and for gasoline supplied by local retailers. The public utility generates its power from a number of sources, including fossil fuel and nuclear, hydroelectric and geothermal energy. P G and E allocates its energy supply according to a priority system for the entire region and could not specifically describe the sources of energy for this location. Similarly, specific sources of gasoline supplies could not be identified.

Shortages of natural gas have already resulted in temporary interruption of service for certain customers in the region, during periods of peak demand during cold winter weather. Electricity shortages, during periods of peak air conditioning demand in summer, may become a serious problem for the region in the near future. Supplies of gasoline are dependent to some degree on foreign imports which have been interrupted in the past and which adversely affect national economic conditions.

ENERGY IMPACT OF PROJECT

Because of the complexity of this project, no attempt has been made to calculate the total energy impact of the general plan proposal.¹ The energy-consuming processes of urban development, which could be set in motion by adoption of the plan, are summarized on the preceding page.

Existing energy input and output on site

Based on 1970 land use data, about 10% of the study area had been converted to urban development, with about 90% left in open space. While areas of urban land use would be energy-intensive, the existing agricultural uses could have a net energy output in some cases, considering the food value of crops produced.²

Comparison of existing and proposed energy use

If adopted, the general plan would set the stage for large-scale conversion of energy-efficient open space to energy-intensive urban development. However, in comparison to existing general plans, this proposal would substantially reduce the amount of urban development planned for the area.

¹See the Chapter 3 case study for a detailed calculation of energy impact due to residential land use.

²See the Chapter 3 case study for a more detailed analysis of energy inputs and outputs for agricultural uses.

MITIGATION MEASURES AND ALTERNATIVES

A. REGIONAL CONTEXT OF PROJECT

1. Contiguous urban development. In planning for new development, urban land uses should be grouped in compact areas. Isolated pockets of proposed "leapfrog" development would result in high per-capita consumption of fuel to reach destinations within the area.

The San Ramon General Plan generally features compact, contiguous development. However, additional low-density residential development proposed along Black Hawk Road and Camino Tassajara is isolated from most community services and facilities; residents in this area would be locked into a dependence on the automobile.

ALTERNATIVE: To reduce long-term gasoline use, additional development proposed along Blackhawk Road and Camino Tassajara could be eliminated from the plan.

2. Timed development.

To reduce the energy problems of scattered development, "timed development" policies could be followed. Under this provision, a site may be planned for eventual conversion to urban land use, but actual development of the site would not take place until most of the suitable land for development closer to existing communities had been built up.

The proposed San Ramon General Plan includes a basic objective of discouraging premature development (page 10). However, this general objective is not backed up by specific holding zone land use categories, in most of the study area.

MITIGATION MEASURE: More specific policies for timed development within the study area, together with the use of "holding zone" categories on the general plan map, could help to discourage energy-wasting premature development within the study area.

3. Access to community facilities and services

The location of schools, shopping centers, parks, and other community facilities within the overall land use pattern can have an important effect on long-term fuel use for transportation. By locating facilities within walking or bicycling distance, residents would not be locked into a dependence on the automobile. In this evaluation, one-half-mile is considered to be convenient walking distance; maximum walking distance to facilities is assumed to be one mile, with a maximum bicycling distance of two miles to reach community facilities.

a. Commercial facilities. As a desirable goal, all urban residential development could be within one-half-mile of a neighborhood convenience shopping center, with a distance of one mile as an acceptable maximum distance. More comprehensive community shopping services could be provided within two miles of all housing.

All residential areas on the General Plan map are within about two miles of commercial facilities. The San Ramon General Plan does not designate locations of local convenience shopping centers. However, a statement is made that "recognition should be given to the need for small convenience centers... each proposed center should be considered on its merits and should be acceptable to the residents in that vicinity." (page 21.)

MITIGATION MEASURE: More specific policies for locating neighborhood shopping centers within convenient walking distance of residential development could be included in the General Plan.

b. Recreation areas. By incorporating parks into areas of new residential development, automobile use to reach recreation areas may be significantly reduced, particularly if parks are within walking distance. A policy of providing linear parks can increase accessibility to open space, and pedestrian trails and bike paths can help in encouraging these alternatives to the automobile.

Nearly all residential development in the proposed plan would be within one mile of park facilities, and a large proportion of housing would be within one-half-mile of parks. However, while trails are proposed in the plan to connect major parks, there is no stated policy of advocating linear parks interwoven throughout the urban area, as opposed to the current practice of setting aside isolated blocks of parkland.

MITIGATION MEASURE: To increase accessibility to open space, and provide greater potential for pedestrian trails and bike paths, a policy advocating the use of linear parks interwoven throughout the urban area could be included in the plan.

c. Schools. If schools are located within walking distance, the use of fuel for school buses and private automobiles could be reduced. Residential development should preferably be within one-half-mile of elementary schools, and within one mile of intermediate and high schools. No policies dealing with school location have been included in the proposed general plan.

MITIGATION MEASURE: To reduce potential need for use of automobiles and buses for transporting students, a policy advocating the location of schools within walking distance of residential development could be included in the general plan.

d. Other community services and facilities. By planning for decentralized community facilities such as libraries, automobile use to reach these destinations can be reduced. Also, decentralized fire stations and police stations can help to reduce fuel use for public vehicles, provide higher standards of safety, and possibly reduce insurance requirements for development in the study area.

Multiple use of public facilities, as advocated in the plan, could reduce energy requirements and financial costs for building and operating facilities. However, no specific policy of decentralized facilities is included in the plan. For example, only one public library

is located in the study area, and the potential for multiple use of school libraries by area residents is not mentioned.

MITIGATION MEASURE: To reduce potential automobile travel, a policy of providing decentralized public facilities could be incorporated in the plan. The general policy of making multiple use of public facilities could be supplemented with a specific policy advocating the opening of school libraries and other school facilities to area residents.

e. Employment centers. By providing dispersed industrial and commercial land uses, some reduction in work commuting distance may be obtained. Within the San Ramon Valley study area, industrial and office uses have been decentralized in several core areas, including Alamo, Danville, San Ramon and San Ramon South. Also, a large area of administrative office and controlled manufacturing has been designated near the Crow Canyon Road interchange, providing multiple opportunities for workers to live near their place of employment.

4. Land use location with respect to public transit

The general plan notes that existing public transportation in the developed portions of the planning area is marginal. The plan states that efforts to provide additional transit service should be encouraged. Land uses are clustered in several "nodes" on the plan map, helping to increase the potential for using public transit to connect these activity centers.

5. Land use location in relation to rail freight service

Shipping goods by rail is much more energy-efficient than relying on trucks. Proposed industrial land uses in the study area have been concentrated along the existing railroad line in the valley, providing the potential for saving energy through use of rail freight by industries in the area.

B. LAND USE CONCEPT

In addition to the locations of land use, a general plan establishes standards for the basic characteristics of development in the study area. The density of development, standards for coordinated planning of new projects, and policies dealing with the type of buildings all may have an important effect on energy use in the study area.

1. Planned development

A coordinated approach to developing new residential areas, shopping centers, and industrial or office areas can provide significant energy benefits and cost savings. While the general plan sets out basic policies of growth for the entire study area, the "planned development" approach refers to a more detailed coordination of improvements on individual properties.

The proposed general plan notes that Planned Unit Development (P-1) Zoning provides flexibility in site planning for projects of 15 acres or more. The plan advocates that these advantages should be made available to smaller projects as well (p. 68). Planned development of administrative office parks is also advocated (p. 24).

2.a. Clustering of residential development

A "Very Low Density Multiple Dwelling" land use category has been included in the plan to provide for clustering of single-family dwellings. The plan also notes that "clustering will be considered to some extent" in low-density single-family residential areas. However, for most areas of residential development, the cluster concept is not specifically encouraged. By grouping housing in clusters whenever possible, significant savings can be made in construction energy input as well as long-term fuel use.

MITIGATION MEASURE: To take advantage of the energy efficiency of clustered development, the proposed opportunity for clustering in certain land use categories could be expanded to other residential designations as well.

2.b. Clustering of commercial development

In addition to residential development, the cluster concept may provide important energy savings, financial benefits, and increased traffic safety for commercial development, in contrast to the energy waste and hazards associated with strip commercial areas. The proposed general plan states that strip commer-

cial development is to be avoided, and this policy is backed by a recommendation to deny land use permits which would aggravate the problem (page 21).

3. Provision for attached buildings

In comparison to equivalent detached units, attached buildings require considerably less fuel for heating and cooling. The proposed general plan states that "single-family areas may include a limited number of attached units where appropriate" (page 18). In the low-density single-family residential category, attached units would be acceptable "where they can be made visually compatible" with existing single-family development. However, the general plan discourages attached units as a general policy:

"A third design objective for the entire area is the prevalence of the single-family detached home. This is preferred to such an extent that even where clustering is considered suitable it is usually recommended to be clustered detached housing." (page 68.)

MITIGATION MEASURE: The use of energy-conserving attached dwellings could be encouraged within those single-family residential categories where use of attached dwellings is not now advocated in the plan. The present policy statement on page 68, discriminating against attached dwellings, could be deleted.

4. High-density residential development

By covering a smaller land area with the same amount of housing, significant energy savings in construction and long-term operation can be achieved. Over 10,000 acres of the study area are proposed for "Country Estate" and "Low Density" single-family residential development of less than three units per acre; housing in these areas is likely to have very high per-capita energy consumption.

MITIGATION MEASURE: To avoid energy waste due to urban sprawl, part of the large area of low-density residential development proposed in the plan could be consolidated into smaller areas of higher density.

C. RELATION OF LAND USE TO PHYSICAL CHARACTERISTICS

The topography, vegetation, drainage patterns, microclimate, and elevation within the study area may have an important bearing on energy consumption for land development. Also, long-term fuel use for heating, cooling and electricity may be affected.

1. Grading and clearance

Location of high-intensity land uses in areas of steep slopes or densely-vegetated areas can aggravate problems of energy use as well as soil erosion. The proposed general plan includes policies of decreasing development densities on steeper slopes (p. 11), of protecting natural tree cover and vegetation (p. 13), and of minimizing disturbance to slopes and natural features due to road construction (p. 14). However, the plan proposes the construction of several roads in areas of very steep terrain, including the extensions of Sycamore Valley Road and Miranda Avenue.

MITIGATION MEASURE: Alternate routes could be chosen for the proposed energy-intensive construction of Sycamore Valley Road, Miranda Avenue and other road extensions in areas of steep slopes, or special standards to reduce grading requirements for these routes could be adopted.

2. Storm drainage and flood control

Construction of storm drainage and flood control improvements can require considerable energy input. As an alternative to the conventional approach of channelizing streams in areas of new development, sufficient open space could be set aside so that a modified natural channel could continue to handle runoff.

The proposed general plan includes a basic objective of "minimizing the man-made characteristics of flood control projects as much as possible" (p. 13). Certain major stream channels are designated as open space on the plan map. However, many of the tributaries of these major streams, which also serve a valuable role as natural drainage channels, are not reserved for open space uses.

MITIGATION MEASURE: To reduce energy input for drainage improvements, additional natural stream courses could be designated as open space on the general plan map.

3. Adaptation to microclimate

The differences in climate which exist within the study area may have a significant effect on long-term energy use for heating and cooling of buildings. The direction that slopes face can influence the amount of sunlight reaching the site; in this study area, a south-facing slope generally

has the most potential for energy-conserving development. Windy sites on exposed ridges can increase winter fuel use, while overly-sheltered locations can block summer breezes.

The general plan does not establish any specific policies for locating development in relation to microclimate. However, the plan includes an objective of keeping hilltops and ridges in open space for aesthetic reasons.

MITIGATION MEASURE: To recognize the energy-conserving value of locating development in areas of favorable microclimate, the general plan could incorporate policies of considering slope aspect and prevailing winds when development patterns are established.

4. Building orientation policies

The orientation of buildings can have a considerable effect on fuel consumption for heating and cooling; lot orientation often determines subsequent building layout. Maximum south window orientation, with proper shading, has been shown to be a good way to conserve energy in climate conditions similar to the San Ramon Valley. However, no policies dealing with building orientation have been included in the general plan.

MITIGATION MEASURE: A policy advocating energy-conserving orientation of lots and buildings could be included in the general plan.

5. Elevation of development

Above a critical elevation, supplementary pumping of water may be required for urban development. Also, supplementary pumping may also be required for sewage systems. By avoiding development in areas where special pumping would be required, or by locating sewage treatment facilities to allow for gravity flow, this energy use can be avoided.

In the San Ramon area, sewage must now be pumped over a natural divide to a treatment plant near Concord, rather than using gravity

flow to existing plants in the area. The plan calls for consolidation of the entire valley into one sewage district, which could eliminate this present pumping requirement.

6. Loss of agricultural productivity

Urban land uses generally consume rather than produce energy. However, energy requirements for agricultural land often are balanced by useful energy outputs in the form of food. In particular, prime agricultural land can be used for intensive energy production.

The proposed general plan includes a basic policy to "protect agriculture for a balance in land use, to meet the long-range needs of the County and for resource conservation." The plan map designates over 15,000 acres of the study area as agricultural open space and agricultural preserve. However, thousands of acres of the most productive lands in the San Ramon Valley are designated for conversion to urban development.

MITIGATION MEASURE: Selected areas of the San Ramon Valley, with high capability for energy production, could be designated for agricultural use.

D. CIRCULATION WITHIN THE STUDY AREA

1. Length of circulation routes

Initial energy inputs for street improvements are closely related to the total length of streets. Any measures to reduce street length in new development, while maintaining adequate circulation, can help in reducing energy consumption. In place of continuous local streets, cul-de-sacs can be used in residential neighborhoods, feeding traffic onto collector streets. However, no policy advocating the use of cul-de-sacs has been included in the circulation element of the proposed plan.

MITIGATION MEASURE: To encourage the conservation of energy required for street construction, a policy advocating the use of cul-de-sacs rather than continuous local streets could be included in the proposed plan.

2. Favorable traffic flow conditions

Although street lengths should be kept to a minimum, the need for convenient, direct traffic flow within the study area should be kept in mind. The general plan should provide a framework of collector streets and arterials which would keep travel distances to a reasonable minimum, routing traffic in the direction of major destination points.

The general plan proposes the completion of several links in the existing collector system to provide more direct access to various points in the community. These include El Capitan, in the Danville area, and Davona Road in the San Ramon area. The long-term fuel savings from shortening the long, circuitous routes which now exist in these areas should outweigh the initial energy input needed for these streets.

3. Street widths

Existing County standards for street widths are based on the need for smooth traffic flow, as well as emergency access requirements. In some cases, however, these needs may be satisfied by reduced standards, thus saving energy for street construction. In particular, the current requirement for a 32' width of local street pavement could be reduced to 26' or less, if adequate regulation of parking would be maintained. At the time of general plan revision, it may be appropriate to review these standards, taking energy conservation and aesthetic values into account. The proposed plan notes,

Short cul-de-sac streets and other very low-volume streets should be reviewed for the possibility of minimizing or doing away with design requirements where this would not hamper accessibility for emergency equipment and where public maintenance costs would not be greater than for conventional design. (page 68)

However, no mention is made of possible reduced width standards for other street categories.

MITIGATION MEASURE: In addition to the proposed general plan policy dealing with reduced standards for local streets, a statement could be included regarding the energy conservation and aesthetic value of reduced collector street and arterial street widths.

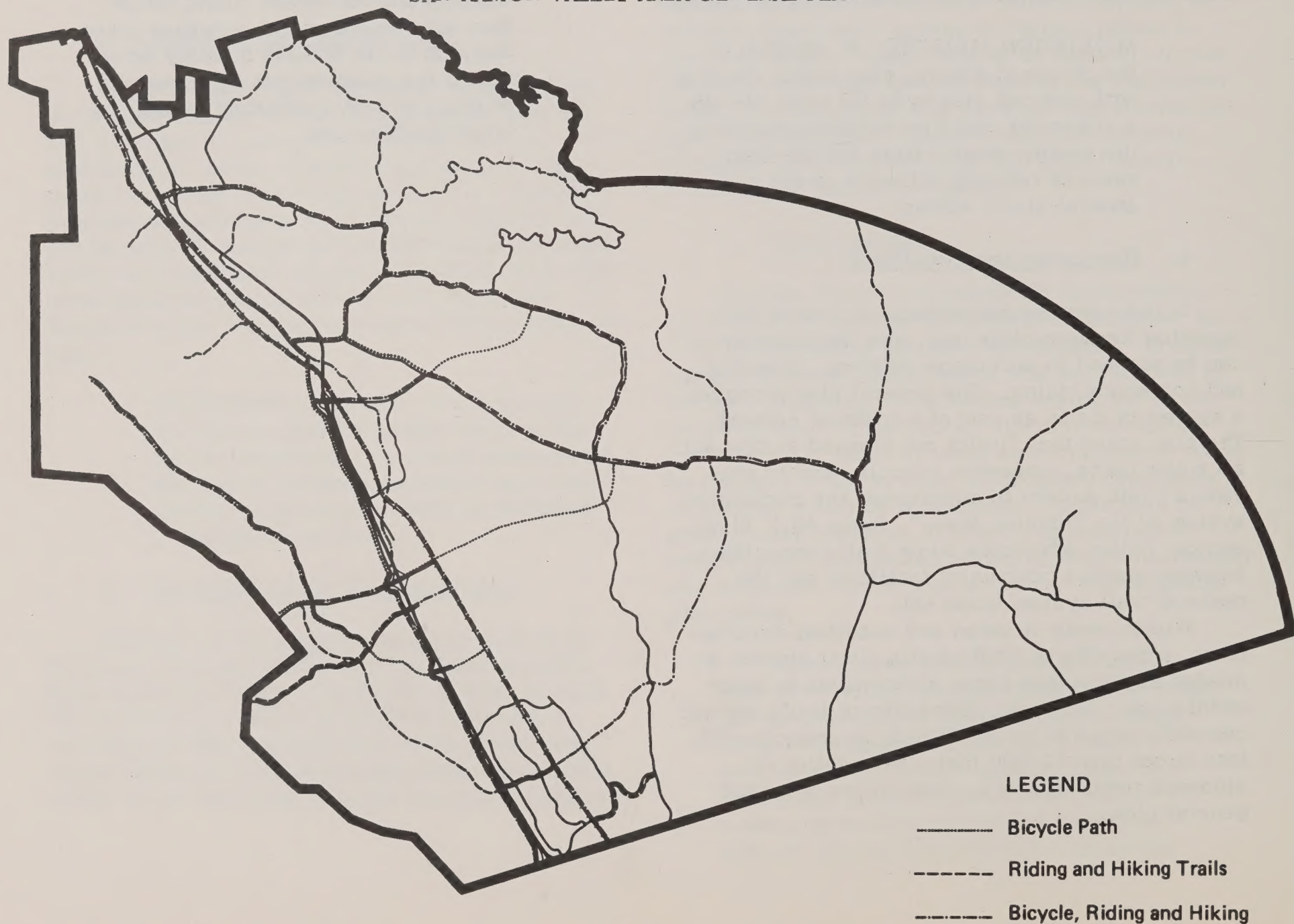
4. Non-motorized circulation

In reducing the dependence on energy consumption for automobile use, new development can be planned to encourage walking, bicycling, and horseback riding. The general plan proposes a system of trails as part of a regional network. The plan notes that "trails are planned to connect all major parks, numerous schools, and to provide a basic pattern to supplement the circulation system of the Planning Area." (page 48.) Also, another policy advocates minor trail connections between various community facilities and the regional trail system (page 48).

Within areas of urban and suburban development, sidewalks or bridle trails along streets are needed to encourage these alternatives to automobile use. However, sidewalks or trails are not generally required by the County in projects with lots larger than 12,000 feet. No mention of sidewalk requirements is made in the proposed general plan.

MITIGATION MEASURE: To encourage walking and horseback riding rather than automobile use in suburban areas, the plan could include a policy advocating the requirements of sidewalks or trails to serve suburban as well as urban development.

FIGURE 2.13
TRAILS PLAN
SAN RAMON VALLEY AREA GENERAL PLAN



E. DETAILED POLICIES FOR URBAN DEVELOPMENT

A number of additional policies concerning details of urban development could provide long-term energy conservation benefits. Policies advocating the following energy conservation measures could be included in the proposed plan.

MITIGATION MEASURES:

1. Use energy-efficient building materials in construction of public facilities.
2. Select energy-efficient street light fixtures.
3. Adopt lot coverage restrictions for unshaded paved surfaces to reduce summer heat build-up and resultant energy use for air conditioning.
4. Require street trees for new projects to reduce summer heat build-up.
5. Use climate-adapted plantings requiring a minimum of resource input for maintenance and irrigation.
6. Advocate solar zoning regulations to protect a landowner's right to sunlight, enabling the reliable use of solar energy.

7. Advocate the collection of methane in sewage treatment plants as an alternate energy source.

8. Relax restrictions on animal-raising in suburban areas where consistent with aesthetics and health, and advocate a policy of providing common gardening areas in multiple-family housing projects, to encourage energy-conserving food production methods.

9. Include a separate energy conservation section of the general plan, dealing with the issues raised in this evaluation and studying the area from an "integrated system" approach to conserving energy.

F. NO PROJECT

If the proposed general plan were not adopted, the present general plans for the area would remain in force. These currently-existing plans call for considerably more urban development than the proposed plan, with development dispersed over a larger area. Thus, the "no project" alternative would result in a greater adverse energy impact, both in terms of total magnitude and energy efficiency of development.

UNAVOIDABLE ADVERSE IMPACTS

No unavoidable adverse impacts would automatically result from plan adoption. However, the plan would set the stage for substantial unavoidable impacts due to future development of the area.

IRREVERSIBLE COMMITMENT OF ENERGY RESOURCES

The plan would not immediately result in irreversible commitment of resources, since the project is a policy statement rather than a proposal for actual construction. However, the plan would set the stage for future irreversible commitment of non-renewable energy sources required for urban development.

SHORT-TERM GAINS VERSUS LONG-TERM BENEFITS

The initial construction of several improvements advocated in the plan, including bicycle paths and collector street links, would add to short-term energy use in the study area. However, long-term fuel savings due to reduced automobile travel distances should outweigh this initial disadvantage.

The long-term benefits of present agricultural energy output within the study area would be eliminated if area proposed for urban uses would be developed.

GROWTH INDUCEMENT AS RELATED TO ENERGY USE

The planned growth of the study area, as proposed in the plan, would inevitably lead to increased total energy consumption within the study area.

3 Evaluation of Energy Impact: Proposed Subdivisions

At first glance, it might not seem that there would be many ways to conserve energy in a new subdivision. Unlike the construction of a housing development or shopping center, a subdivision mainly involves some property lines drawn on a piece of paper; the developer is usually responsible only for the construction of streets, utilities and some other site improvements.¹ However, at the time the subdivision is laid out, some basic decisions are made which will affect the way that energy is used for years in the future.

The orientation of lots, the layout of streets, and the restrictions on future construction in the subdivision can all be vital in determining whether energy will be wasted or conserved by future residents. For example, people living in a subdivision with convenient bike paths and sidewalks leading to nearby schools and stores will probably drive automobiles much less than residents of a remote project without these

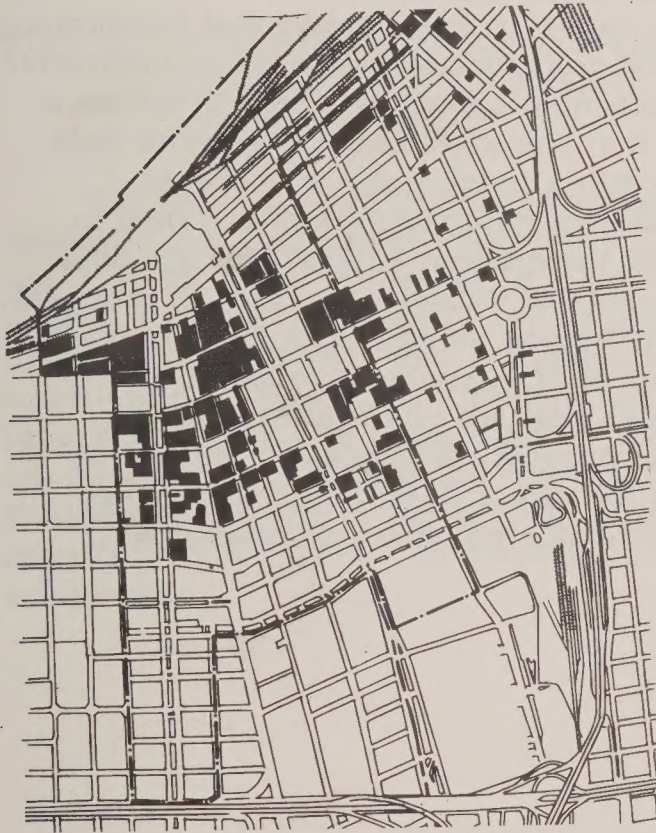
¹It should be noted that the term "subdivision" is often loosely used to describe a housing project built by a developer. This chapter, however, deals only with the energy implications of land division and initial site improvements, while making general assumptions about future housing on the site. The more detailed energy issues relating to building construction are discussed in Chapter 4.

alternatives to the automobile. Also, if climate conditions are properly considered when a new subdivision is planned, future homeowners can keep their use of heaters and air conditions to a minimum. If climate is ignored initially, however, energy waste may be permanently built into the project.

In preparing an energy component for a subdivision, it is important to concentrate on issues which are the responsibility of local governments. It is useless to go into detail on issues (such as regulation of natural gas prices) which are handled at state and national levels. Of course, it is important to gain a general understanding of conventional energy sources, particularly when shortages may be involved, but the compiling of detailed information on conventional energy sources is of marginal value in evaluating a subdivision. Local governments can make a meaningful contribution to energy conservation, however, by establishing energy-efficient land use and circulation patterns, and to some extent by encouraging alternative energy sources, and these are the points that should be emphasized in evaluating a subdivision.

In this chapter, a method for preparing the energy component of an environmental impact report is outlined. Phase 1 involves the collection of base data; Phase 2 deals with analysis of energy use in the proposed project; and Phase 3 outlines a method for identifying problems and selecting possible alternatives and mitigation

measures (this selection procedure is summarized in the checklist at the end of the chapter). Finally, Phase 4 deals with the presentation of this information in the E.I.R., including the descriptions of unavoidable impacts, irreversible commitment of resources, short-term versus long-term impacts, and growth inducement as related to energy use.



Phase 1: Inventory

In gathering background information for the energy component of the E.I.R., it is important to avoid unnecessary duplication of efforts. Most of the data needed for the energy component is also required in preparing other sections of the E.I.R.; the team of analysts preparing the various components should divide up the task of collecting information.

Table 2.1 is a summary of the background information needed for evaluating the energy impact of proposed development. Special site or project conditions may dictate the deletion or addition of certain items, and the degree of detail for each item will vary from project to project. Typical sources of information are indicated in the table. Since the energy impact of a project will often depend on the interrelationship of several variables, it is advisable to obtain as much background information as possible before proceeding with analysis of the data. All energy units should be expressed in BTU's, using the conversion tables in Appendix D if necessary. This background information will later be summarized in various sections of the E.I.R.

Phase 2 : Analysis of Proposed Energy Use

Based on the information compiled in the inventory phase, a clear picture should be drawn of the energy demand of the proposed project. This analysis should include a comparison of the types of energy which would be used by the project with the long-term availability of these types of energy.

Identification of Energy Impacts

All energy-consuming processes for construction or other site alteration and operation of the subdivision should be identified. Table 1.11 is a summary of the types of initial and long-term energy impacts of a typical residential land use element such as a subdivision.

A procedure for calculating total (direct and indirect) energy inputs has been assembled and organized in a manner that gives the planner a step-by-step format for a relatively simple analysis with the flexibility of exploring any of various steps in greater detail and with increased accuracy. The three steps are as follows:

Step I Preparation of background data

Step II Computations

Step III Evaluation

In some cases it may not be possible to complete this evaluation because of time limitations or lack of base data. If this is the case, efforts can be concentrated on calculating selected energy inputs which may be of prime concern in the particular situation.

In other cases, it may happen that topography, climate, local construction practices or innovative design and planning approaches tend to create a subdivision that has sufficient diversity to defy the classifications used in the worksheets. There is sufficient detailed background data in this report for the diligent analyst to track down the energy inputs of virtually any project proposal. Figure 1.8 will prove helpful in finding the more detailed sources of information found in the summary tables that are cited in this section. Table A.18 in Appendix A provides a method for breaking out the direct (fuel) costs for certain types of subdivision construction operations.

STEP I: PREPARATION OF BACKGROUND DATA

Table 3.2 may be used as both a guide and worksheet for simple analyses or as a guide only for more detailed or complex analyses. Opposite each step in the preparation procedure is an indication of the source and format for the information required.

STEP II: COMPUTATIONS OF A 20-YEAR COMMITMENT FOR ENERGY CONSUMPTION

The data acquired in Step I may be used to complete the calculation worksheets (Tables 3.3 and 3.4) for Steps II.A and II.B. For more complex or detailed analyses it may be useful to divide the subdivision into components and, following the same format, perform the calculations for individual components. The sum of all the direct and indirect energy inputs from the right-hand columns is the 20-year long-term commitment for energy consumption in the subdivision.

STEP III: ANALYSIS OF DEVELOPMENT ALTERNATIVES

The energy impacts calculated in Steps I and II may be compared with those of alternate developments as well as continuation of the existing use (the "no project" alternative) using Tables 3.6 and 3.7 as worksheets for each alternative.

By using the comparisons of energy utilization per unit, per person, and per unit geographical area, the analyst will have a circumspect understanding of the energy picture. For example, a project with a low energy input per acre might exhibit a high energy input per person or per unit. Subdivisions which are rapidly occupied represent a better use of resources than tracts with sparse development with underused roads and utilities because the energy required for both construction and maintenance is spread over more total users.

As an additional exercise, the analyst might want to divide any of the figures in the right-hand column of Table 3.6 by 20 years to arrive at an average energy input per year.

TABLE 3.2

STEP I
INFORMATION PREPARATION FORM
ENERGY INPUTS FOR A RESIDENTIAL SUBDIVISION

STEP	ITEM	OPERATION	REFERENCE	ENTER DATA
I.A.	Neighborhood development pattern.	Compare and select most applicable type from table.	Tables 1.3 and 1.4 and applicant's proposed zoning densities.	☐ A. Single Family ☐ B. Single Family ☐ C. Townhouse ☐ D. Walk-Up ☐ E. High-Rise ☐ F. Housing Mix
I.B.	Street lengths.	Computation.	Subdivision map.	Ft. Total street length
I.C.	Energy inputs per linear foot of street.	Select from table depending on type of construction.	Table 1.5.	BTUx10⁵ BTU per linear foot at street (Direct and indirect)
I.D. (Optional)	Dollar cost of other initial site improvements.	Calculate using conventional methods.	Use developer's estimate or <u>LSI Current Construction Costs 1976.</u>	\$ Total dollar costs
I.E. (Optional)	Energy inputs per construction dollar for other initial site improvements.	Select from table depending on type of construction.	Table 1.1.	BTUx10⁵ BTU per construction dollar (Direct and indirect)
I.D.	Quantity of residential units.	Compute maximum number of residential units allowed under projected densities.	Maximum allowable densities for multi-family and lot count for single family.	Number of units: ☐ A. Single Family ☐ B. Single Family ☐ C. Townhouse ☐ D. Walk-Up ☐ E. High-Rise
I.E.	Energy input per residential unit for construction.	Select from table depending on development pattern type.	Table 1.5.	BTUx10⁵ BTU energy input for residential unit for construction (Direct and indirect).

STEP	ITEM	OPERATION	REFERENCE	ENTER DATA
I.F.	Build-out factor.	Predict time period in which building improvements will reach allowed density and select factor from table.	Table 1.10.	 Build-out factor.
I.G. (Optional)	Dollar cost of neighborhood facilities (cost allocated to project).	Calculate using conventional methods.	<u>LSI Current Construction Costs 1976.</u>	\$ Total dollar costs.
I.H. (Optional)	Energy inputs per construction dollar cost for neighborhood facilities.	Select from table depending on type of construction.	Table 1.1.	BTUx10⁵ BTU per construction dollar (Direct and Indirect).
I.I.	Energy inputs per residential unit for operation and maintenance of utility infrastructure (20 years).	Select from table depending on development pattern type.	Table 1.5.	BTUx10⁵ BTU energy inputs per residential unit for operation and maintenance of utility infrastructure (Direct and Indirect).
I.J.	Energy inputs for residential building operation (20 years).	Select from table depending on location and development pattern type.	Table 1.6.	BTUx10⁵ BTU per residential unit (Direct only).
I.K. (Optional)	Gross area of neighborhood facility by type.	Estimate by analyst.	None.	S.F. Gross area.
I.L. (Optional)	Energy inputs per gross square foot for neighborhood facility operation.	Select from table depending on building type.	Table 1.7.	BTUx10⁵ BTU per gross square foot per year.
I.M. (Optional)	Projected operation of neighborhood facility.	Estimate by analyst.	None.	Years Years of operation.

TABLE 3.3

STEP II
/ CALCULATION WORKSHEET
INITIAL ENERGY INPUTS FOR A RESIDENTIAL SUBDIVISION

II.A.1	L.F. Total street lengths (Table 3.4, Step I.B.).	x	BTUx10⁵ BTU's per linear foot (Table 3.4, Step I.C.).	=	BTUx10⁵ Total initial energy inputs for street and utilities (Direct and indirect).
II.A.2	\$ Total dollar cost of other site improvements (Table 3.4, Step I.D.).	x	BTUx10⁵ BTU's per construction dollar (Table 3.4, Step I.E.).	=	BTUx10⁵ Total initial energy inputs for other site improvements (Direct and indirect).
II.A.3	SUBTOTAL OF INITIAL ENERGY INPUTS				BTUx10⁵

TABLE 3.4

STEP II
CALCULATION WORKSHEET
LONG-TERM ENERGY INPUTS FOR A RESIDENTIAL SUBDIVISION
(Direct and Indirect Inputs)

STEP	20-Year Long-Term BTU Energy Input					
II.B.1	units Number of units by type (Table 3.4, Step I.D.).	x	BTUx10⁵ Direct and indirect BTU energy input per unit (Table 3.4, Step I.E.).	x	 Proportion of units built within 20 years (100% = 1.0).	= BTUx10⁵ Residential construction.
II.B.2	\$ Pro-rated dollar cost of neighborhood facilities (Table 3.4, Step I.G.).	x	BTUx10⁵ Direct and indirect energy input per dollar of construction cost (Table 3.4, Step I.H.).	x	 Proportion of construc- tion within 20 years (100% = 1.0).	= BTUx10⁵ Neighborhood facilities construction.
II.B.3	units Number of units by type (Table 3.4, Step I.D.).	x	BTUx10⁵ Direct and indirect energy input per unit for operation and maintenance of utility infrastructure (Table 3.4, Step I.I.).			= BTUx10⁵ Utility operation and maintenance.
II.B.4	units Number of units by type (Table 3.4, Step I.D.).	x	BTUx10⁵ Energy input per unit for residential building operation (Table 3.4, Step I.J.).	x	 Build-out factor (Table 3.4, Step I.F.).	= BTUx10⁵ Residential operation.
II.B.5	S.F. Area of neighborhood facilities by type (Table 3.4, Step I.K.).	x	BTUx10⁵ Energy input per square foot per year of neighbor- hood facility (Table 3.4, Step I.L.).	x	years Estimated years of operation (Table 3.4, Step I.M.).	= BTUx10⁵ Neighborhood facilities operation.
II.B.6	Transportation energy inputs over 20-year period (optional).					= BTUx10⁵

TABLE 3.5

SUMMARY OF ESTIMATED ENERGY INPUTS FOR PROJECT

	BTU x 100,000 (therms)
INITIAL ENERGY INPUTS	
Streets and utility construction	
Other site improvements	
SUBTOTAL: _____ BTU x 100,000	
LONG-TERM NON-TRANSPORTATION ENERGY INPUTS (20-year period)	
Residential construction	
Neighborhood facilities construction ¹	
Utility operation and maintenance	
Residential operation	
Neighborhood facilities operation ¹	
SUBTOTAL: _____ BTU x 100,000	
TOTAL NON-TRANSPORTATION ENERGY INPUT (20-year period)	
TRANSPORTATION ENERGY INPUT (optional)	
TOTAL TWENTY-YEAR ENERGY IMPACT OF PROJECT ²	
INITIAL INPUT PER RESIDENTIAL UNIT ²	
PER GROSS ACRE ²	
TOTAL INPUT PER RESIDENTIAL UNIT ²	
PER GROSS ACRE ²	

¹Construction and operation of neighborhood facilities should be pro-rated as necessary to reflect situations where the facility may serve residents of the surrounding area as well as people living in the subdivision. For example, 25% of the energy cost for constructing and operating a school should be included if only 1/4 of the school's students come from the subdivision.

²Specify whether or not transportation inputs are included.

TABLE 3 - 6

ANALYSIS WORKSHEET FOR DEVELOPMENT ALTERNATIVES

INITIAL ENERGY INPUTS

a.	$\boxed{\text{BTU} \times 10^5}$ Initial Energy Input (Table 3.5-Step II.A.3)	$\div$	$\boxed{\text{UNITS}}$ Maximum No. of Dwelling Units (Table 3.4-Step I.D)	=	$\boxed{\text{BTU} \times 10^5}$ BTU Per Residential Unit
b.	$\boxed{\text{BTU} \times 10^5}$ Initial Energy Input (Table 3.5-Step II.A.3)	$\div$	$\boxed{\text{PERSONS}}$ Maximum No. of Residents (Table 1.3)	=	$\boxed{\text{BTU} \times 10^5}$ BTU Per Resident
c.	$\boxed{\text{BTU} \times 10^5}$ Initial Energy Input (Table 3.5-Step II.A.3)	$\div$	$\boxed{\text{ACRES}}$ Gross Project Area (Subdivision Map)	=	$\boxed{\text{BTU} \times 10^5}$ BTU Per Gross Acre

20-YEAR PROJECTED ENERGY INPUTS

a.	$\boxed{\text{BTU} \times 10^5}$ Total Energy Inputs (Table 3.5-Step II.A.3 + Table 3.6-Step II.B.7)	$\div$	$\boxed{\text{UNITS}}$ Projected No. of Dwelling Units (Table 3.4-Step I.D) x Build Out Factor (Table 3.4-Step I.F)	=	$\boxed{\text{BTU} \times 10^5}$ BTU Per Residential Unit
b.	$\boxed{\text{BTU} \times 10^5}$ Total Energy Inputs (Table 3.5-Step II.A.3 + Table 3.6-Step II.B.7)	$\div$	$\boxed{\text{PERSONS}}$ Project No. of Residents (Table 1.3) x Build Out Factor (Table 3.4-Step I.F)	=	$\boxed{\text{BTU} \times 10^5}$ BTU Per Resident
c.	$\boxed{\text{BTU} \times 10^5}$ Total Energy Inputs (Table 3.5-Step II.A.3 + Table 3.6-Step II.B.7)	$\div$	$\boxed{\text{ACRES}}$ Gross Project Area (Subdivision Map)	=	$\boxed{\text{BTU} \times 10^5}$ BTU Per Gross Acre

TABLE 3.7

CALCULATION OF EXISTING ENERGY INPUTS AND OUTPUTS ON SITE

A. EXISTING AGRICULTURAL ENERGY INPUT

(20-year period; continuing direct inputs for crop production).

$$\boxed{} \frac{1000 \text{ kcal}}{\text{ton}} \times \boxed{} \frac{\text{tons}}{\text{acre}} \times \boxed{} \text{ acres} \times \frac{.04 \text{ BTU} \times 10^5}{1000 \text{ kcal}} \times 20 \text{ yrs.} = \boxed{} \text{ BTU} \times 10^5$$

Fuel and electrical energy input. (Table 1.5). Average crop yield. Area of site in agricultural use.

B. OTHER EXISTING ENERGY INPUT ON SITE (projected over 20 years)

=

 $\boxed{} \text{ BTU} \times 10^5$

C. TOTAL EXISTING ENERGY INPUT ON SITE (A + B)

=

 $\boxed{} \text{ BTU} \times 10^5$

D. EXISTING AGRICULTURAL OUTPUT ON SITE (20-year period)

$$\boxed{} \frac{1000 \text{ kcal}}{\text{ton}} \times \boxed{} \frac{\text{tons}}{\text{acre}} \times \boxed{} \text{ acres} \times \frac{.04 \text{ BTU} \times 10^5}{1000 \text{ kcal}} \times 20 \text{ yrs.} = \boxed{} \text{ BTU} \times 10^5$$

Crop caloric content (Table 1.5). Average crop yield. Area of site in agricultural use.

E. NET EXISTING ENERGY INPUT ON SITE (C - D, if C is larger)

-or-

NET EXISTING ENERGY OUTPUT ON SITE (D - C, if D is larger)

 $\boxed{} \text{ BTU} \times 10^5$ $\boxed{} \text{ BTU} \times 10^5$

F. NET EXISTING INPUT PER GROSS ACRE

-or-

NET EXISTING OUTPUT PER GROSS ACRE

 $\boxed{} \text{ BTU} \times 10^5$ $\boxed{} \text{ BTU} \times 10^5$

Phase 3 :

Identification of Problems, Mitigation Measures, and Alternatives

In the following paragraphs, basic energy conservation issues involving subdivision development are identified. These topics have been organized in order of increasing detail, ranging from the generalized issues of the site location within the region, to the energy implications of specific site improvements.

In completing this phase, there is a basic problem in deciding when energy use is "wasteful." All subdivisions will require the consumption of energy, and there is a lack of standards for measuring energy efficiency of subdivisions. In this report, the use of energy is considered to be wasteful if it can be avoided through use of a feasible alternative or mitigation measure. Thus, even if a project is highly energy-efficient, there is room for improvement.

Using the energy evaluation checklist

To aid in determining which problems and possible mitigation measures or alternatives apply to a particular project, an energy evaluation checklist for proposed subdivisions has been provided at the end of this chapter. To use the checklist, each energy conservation problem should be reviewed to see if it applies to the particular project under study. If so, one or more possible mitigation measures or alternatives to reduce the energy impact may be selected, based on the discussion in the text.

An alternative is considered to be a suggestion which would require extensive changes in the location or design of the project, while a mitigation measure is more of a "band-aid" action which can be adopted without major alterations to the project. However, there is no clear line between the two categories, and the classification in the checklist is only intended as a general guide.

There is, of course, a great deal of overlap among these problems and possible solutions. The cross-reference column at the right of the checklist is provided to help in identifying these interrelationships, so that duplication of material can be kept to a minimum.

It should be noted that the alternative of "no project" is discussed separately at the end of the section.

A. SITE LOCATION IN A REGIONAL CONTEXT

The location of the project within the region may have a major effect on the type and quantity of energy used within the subdivision. The following energy issues should be considered:

1. Dependence on the automobile: Is the site location remote from existing services, public facilities and places of work? Are more suitable locations for this type of development available, requiring less automobile use?

2. Construction and operation of utilities: Is the site served by existing utility lines, or will new lines be needed, requiring energy input for materials and construction? Will electrical services to the site result in significant transmission line losses?

If the site is in a remote location, or lacks convenient access to community facilities and services, the following alternatives and mitigation measures are available:

ALTERNATIVES

A-1. Selecting an alternate site, if suitable land is available in a more favorable location.

G-1. No project (discussed on page 136).

MITIGATION MEASURES

A-2. Concentrating on self-contained development, with services and facilities located on-site. (NOTE: Self-contained utilities, as a more detailed issue, are discussed on page 131).

A-3. Provision of mass transit for off-site trips.

In the following paragraphs, three of these alternatives and mitigation measures are discussed in more detail. (The alternative of "no project" is common to many energy conservation problems, and thus is a special case to be treated separately in preparing the E.I.R.) The trade-offs (conflicts vs. benefits) which could result from application of each measure are also noted.

1. "Leapfrog" development versus contiguous urbanization.

In an energy-conserving community, new development takes place on land adjacent to existing built-up areas, with convenient access to community facilities. Often, however, developers seek to subdivide cheap land far beyond the existing developed areas. In addition to the extra costs to local government for providing services to "leapfrog" development, there is a waste of energy. Residents of "leapfrog" subdivisions tend to drive more, since shopping centers, schools and offices are farther away; walking and bicycling often become more difficult.

Extra energy is also needed for construction of streets and utility lines to reach the project, and there is additional transmission loss in providing electricity.

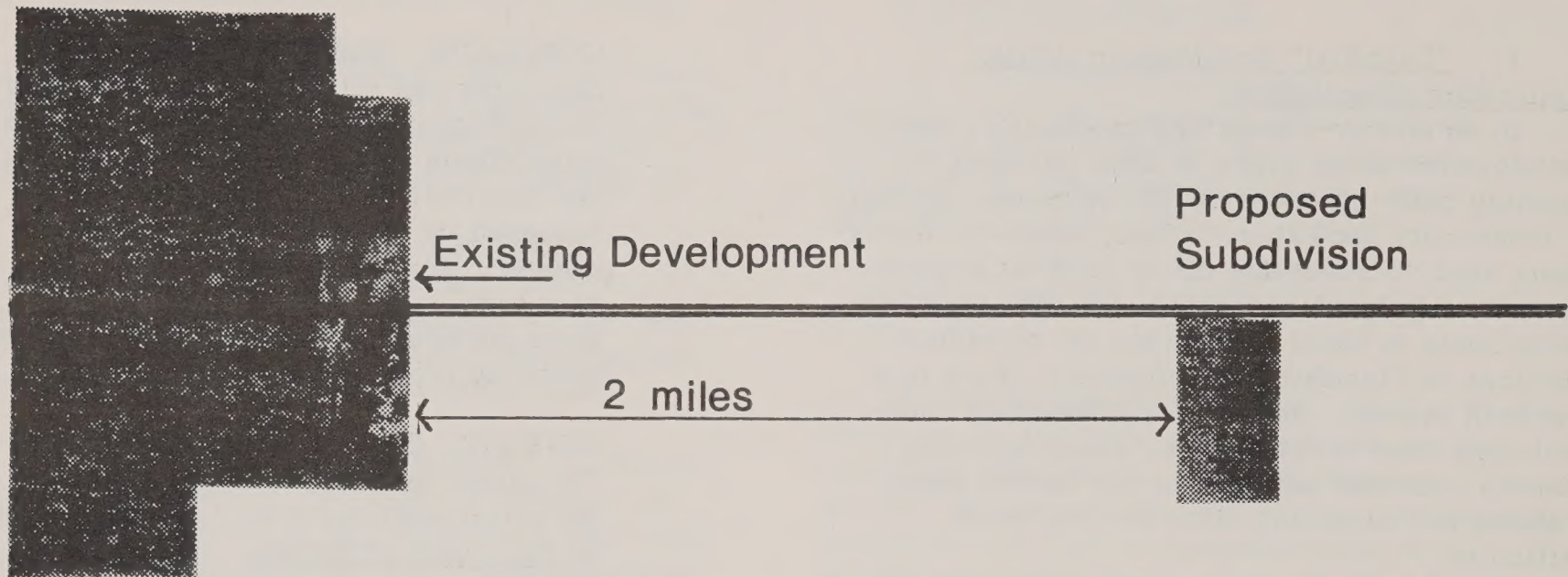
A 1 ALTERNATIVE: To avoid energy waste due to "leapfrog" development, another site closer to existing community facilities may be selected for the project.

APPLICABILITY: All climate zones. Primary-home "leapfrog" subdivision. With second-home subdivision, relationships to major recreation attractions are additional considerations.

CONFLICTS: Higher first costs to the developer and lot purchasers may result, due to higher land costs for alternative sites closer to the existing community, but this cost to the lot buyer will be balanced by reduced expenses for driving. The developer's lower first cost may actually be a subsidy, with local governments picking up the excess costs for providing services.

BENEFITS: Compact growth rather than "leapfrog" development saves money for government services, as documented in The Costs of Sprawl. Compact development, with unspoiled greenbelts, has aesthetic and environmental advantages, and more convenience to residents is provided.

EXAMPLE: A new ten-lot subdivision is proposed two miles outside the city fringe, with on-site water supply and sewage disposal. The proposal does not include any public facilities such as parks or schools. Land appropriate for development is located on the city fringe. The energy waste due to increase automobile use caused by this "leapfrog" subdivision, in comparison to new development immediately adjacent to the city fringe, can be estimated by the following procedure.



Based on traffic surveys in the area, each residential unit (when homes are built in the subdivision) would generate ten one-way trips per day. If all of these homes would be built immediately, the ten units would generate a total of 36,500 trips per year. However, it is estimated that it will take about five years for the subdivision to be fully occupied. From Table 1.10, the "build-out factor" over the standard 20-year base period would be 0.9; the vacant lots during the first five years would not be generating traffic, so the average yearly trip generation would actually be about 33,000 trips.

In this case, all trips will be to points in the existing community or beyond. In comparison with the alternate "fringe" location, the proposed "leapfrog" subdivision two miles further from the city would require about 66,000 extra miles of driving per year. At 15 miles per gallon of gasoline, and 275,000 BTU's of direct and indirect energy input per gallon of gasoline (from Tables E-1 and 1.2), the leapfrog subdivision would require 24 billion more BTU's over a 20-year period, compared with the fringe subdivision. This wasted energy would be the equivalent of about 4,000 barrels of crude oil.

2. Self-contained development.

In large projects, the problem of remote location may be reduced by providing various services and facilities within the subdivision to cut down on automobile use. Schools, parks, recreation facilities, shopping areas, day care centers or other facilities may be included, depending on the size of the project. Even though a new subdivision may not be large enough on its own to support these facilities, the needs of the surrounding area should be kept in mind.

In addition to conventional commercial facilities, neighborhood co-operatives can be valuable in reducing the use of automobiles. The potential inclusion of a "co-op" store, run by a homeowners' association, may be considered when community facilities are planned. Fruits and vegetables grown by homeowners could be exchanged in open-air markets; increased use of locally-grown produce could reduce dependence on energy-intensive agriculture, decrease the need for automobile use, and provide a chance for neighbors to socialize. While detailed plans for these activities would usually not be made at the time of subdivision design, it is important to consider space needs, and to avoid regulations which would prevent these activities from taking place in the future.

In a planned development, it may be beneficial to group various local facilities in a community center. In addition to meeting rooms and recreational facilities, space for cooperative markets and day care centers could be provided.

The use of decentralized, on-site energy sources for a new project can diminish the total energy impact, as well as reduce the demand for scarce conventional fuels. This potential mitigation measure is discussed in detail on page 131.

A2

MITIGATION MEASURE: Dependence on the automobile may be reduced by providing neighborhood facilities in new developments. In addition to parks and schools, local convenience shopping facilities, food cooperatives, and open-air markets may be provided for large projects.

APPLICABILITY: Large projects in all climate zones.

CONFLICTS: School sites and parks are an extra cost for the developer. Some homeowners may object to neighborhood shopping facilities for aesthetic reasons, although imaginative design can usually reconcile this conflict. There is a trade-off between providing park sites and planning compact development (see page 107); the overall density of the project will be reduced by providing parkland, but this local facility will reduce the need for driving to reach distant parks.

3. Mass transit and specialized transit systems.

In many areas of the County, mass transit is virtually non-existent. However, some bus feeder lines to the Bay Area Rapid Transit system have recently been added, and bus service is provided to some unincorporated areas as well as cities in the Richmond area. In the case of large projects, existing bus lines might be rerouted to serve new development; covered enclosures should be provided at bus stops.

Even though there may be no existing rail or bus service in other areas, the potential for mass transit should be taken into consideration. In large projects, the creation of "nodes" with community facilities and high-density residential development can later serve as a good bus stop location. Where no public mass transit system is available for large projects, developers or homeowners' associations might operate private buses to connect the project with rapid transit stations or other nearby destinations.

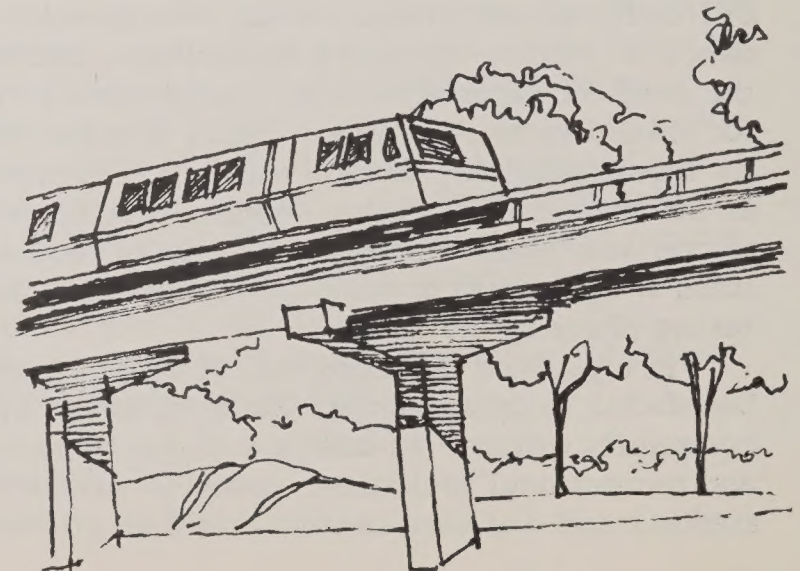
Other innovative alternatives to the automobile should be encouraged in large developments. "Car-less" subdivisions are one possibility; automobiles could be left in lots at the entrance to the project, and golf carts or other small vehicles could then be used for travel within the project.

A3 MITIGATION MEASURE: The use of mass transit may be encouraged in new projects by providing convenient access to existing transit systems, planning of "nodes" for future transit service, or operation of private buses or other energy-efficient alternatives to the automobile.

APPLICABILITY: Large projects in all parts of the county.

CONFLICTS: Construction of bus stop enclosures or operation of private transit systems would add to developers' costs.

BENEFITS: Reduction of air pollution, as well as long-term energy savings.



B. DEVELOPMENT CONCEPT

In addition to the location of a proposed project, the nature of the development on the site will have an important effect on energy consumption. Several basic energy issues should be considered:

1. Construction: Is development grouped compactly on the site, providing for efficient use of energy for construction of the project, or will a dispersed pattern of development lead to inefficient energy use?
2. Transportation: Does the proposed development pattern encourage energy-efficient means of circulation, or will residents be locked into a dependence on the automobile?
3. Home heating and cooling: Will the proposed project establish a land-use pattern which includes energy-efficient housing types?

If the proposed development features low-density, dispersed, single-family housing, the following alternatives can be considered:

B-1. Clustering of lots for detached single-family dwellings, with no increase in the total number of units on the site. (Alternative.)

B-2. Zero-lot-line regulations or flexible setbacks, with no increase in the total number of units on the site. (Mitigation measure.)

B-3. Higher-density development, if consistent with site conditions and availability of services. (Alternative.)

These three suggestions may be made individually or together. The greatest reduction in total energy impact of the project could be gained with the first two measures. The total energy impact would be increased with the alternative of higher-density development, but the energy efficiency per unit would be improved. Higher-density development should be suggested only if available energy supplies to the site are not reaching a saturation point.

Clustering of lots for detached single-family dwellings

As an alternative to conventional subdivision, clustered housing is one of the most important ways to conserve energy in new residential development. In place of the typical subdivision, where residential units are spaced more or less evenly over the entire property to be developed, the residential units are grouped together on certain portions of the site. Conservation benefits are greatest if attached dwellings are used (see following section), but single-family homes clustered together on smaller lots also can provide significant energy savings. There are three basic reasons why cluster development saves energy in comparison with conventional subdivisions:

1. Initial energy input is reduced, since less site alteration and construction of streets and utilities is needed for each residential unit.
2. Shorter street lengths also mean that less driving is necessary to reach the residential units.
3. The open space made available by clustering the homes can be used for hiking, bicycling, or bridle trails, providing an attractive alternative to automobile use within the project and reducing the need for driving to reach distant recreation areas.

Cluster development is particularly advantageous when portions of a site have natural features (such as hilly terrain or stream courses) which would require extra energy input for development. Instead of boxing streams into culverts and grading on steep hills, these areas can be reserved for recreational use while development is grouped on other parts of the site.

B1

ALTERNATIVE: To reduce energy impact due to construction and transportation, clustering of lots for single-family detached dwellings may be considered as an alternative to conventional subdivision development.

APPLICABILITY: Conventional subdivisions of approximately 30 units or larger. Cluster development may also be used for smaller subdivisions, although it may be difficult to establish a viable homeowners' association for proper maintenance of small projects.

CONFLICTS: Since private yard areas for each unit are reduced, energy-conserving vegetable gardening may be discouraged unless common areas are providing for this purpose. Cluster developments often hinder the ability for expression of personal aesthetic tastes. Developers often are hesitant to undertake the extra work of establishing a homeowner's association.

BENEFITS: Properly designed cluster developments have general environmental benefits due to the increased areas of open space and reduced need for site alteration. Costs per unit for the developer are considerably less than comparable non-clustered development.

2. Zero-lot-line regulations and reduced setbacks

More efficient use of land, and thus more energy-efficient development can be achieved through the use of "zero-lot-line" regulations. Basically, the zero-lot-line concept allows a building to extend to the property line on one or more sides. This and other flexibility in building setbacks can have two basic benefits. First, zero-lot-line regulations can provide more efficient use of the lot for detached single-family homes; the typically narrow side yards can be combined on one side of the house, providing usable outdoor space and opening the possibility of smaller lot sizes. Reduced setbacks for front or rear yards, when consistent with public safety requirements, can also be beneficial in establishing energy-efficient land use patterns. More important, energy-efficient attached dwellings can be built if zero-lot-line regulations are

provided for this purpose. While zero-lot-line regulations or reduced setbacks are typically considered together with cluster development, their controlled use in conventional subdivisions may also help in conserving energy.

B2

MITIGATION MEASURE: Zero-lot-line regulations and reduced yard setbacks may be applied to achieve more energy-efficient land use patterns, particularly if regulations allow attached housing units.

APPLICABILITY: Conventional subdivisions in all climate areas.

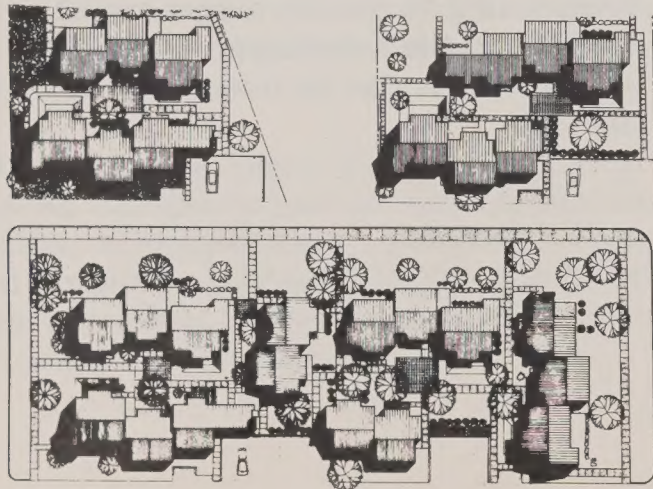
CONFLICTS: Proper planning is needed to avoid fire hazards in attached dwellings, or aesthetic problems with detached dwellings crowded together.

BENEFITS: In addition to energy savings, lower costs to the developer result in savings to the homebuyer. Outdoor space on lots can be used more efficiently.

3. Higher-density development

The size of lots in a new subdivision is usually set by the minimum zoning requirements for the property. It may be worthwhile to take a second look at these restrictions, since from an energy conservation standpoint, it is best to have minimum lot sizes and maximum densities consistent with site conditions. There may be some limitation on the overall number of lots, such as the size of streets and utility lines serving the property. In this case, clustering of units on one part of the property, or providing zero-lot-line regulations, can be important ways to save energy.

Looking at energy use in a regional context, however, it may be beneficial to increase the total number of units on the property. While this increased density would result in a greater total energy impact, the energy efficiency per unit may be improved with somewhat higher density.



B3

ALTERNATIVE: To avoid excessive energy use due to urban sprawl, minimum lot sizes and maximum densities may be considered where consistent with site conditions and availability of services.

APPLICABILITY: All County climate conditions. This recommendation may be appropriate for low-density subdivisions if (a) adequate streets and utilities are available to serve additional population; (b) environmental damage will not be substantially increased; and (c) the reduced lot size would adequately handle the type of residences anticipated on the lots.

CONFLICTS: Without careful planning, the increased densities might result in a "packed-in" appearance. However, imaginative use of open space, street trees and other design features can help to maintain visual qualities of the subdivision, even at somewhat higher densities. Homeowners with smaller lots may be hampered in individual efforts to save energy by planting large vegetable gardens or raising animals; common areas could be provided for this purpose.

BENEFITS: Smaller lots will mean lower costs to the developer, resulting in savings to the homebuyer. Energy usage will be lower per unit, due to reduced street lengths needed to serve smaller lots.

C. SITE PLAN: LOT LAYOUT

After considering the project location and development concept, a more detailed evaluation of the subdivision layout can be made. Redesign of the project may have the following effects on energy use:

1. Initial energy use for site clearance, grading, storm drainage improvements, and demolition may be reduced by redesign on the lot layout.

2. Home sites in unfavorable microclimatic areas of the site may be shifted to better locations, reducing future demands for home heating and cooling. Redesign of lots with unfavorable orientation may also reduce energy use for home heating and cooling.

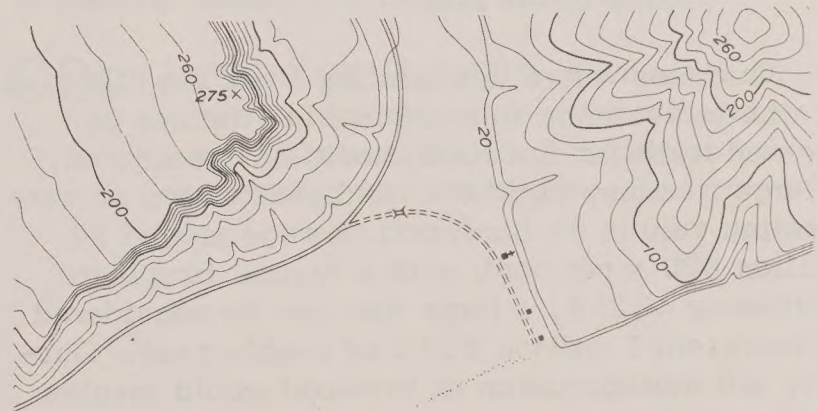
3. Long-term electricity use for pumping of water and sewage may be avoided or reduced by relocating homesites in problem areas.

In the following sections, the available mitigation measures and alternatives to achieve energy savings are discussed in detail. While suggestions for improving lot layout and internal circulation are treated separately in this report, the close relationship between the two should be kept in mind.

1. Grading and clearance

Location of homesites in areas of steep slopes can aggravate problems of energy use as well as soil erosion. In addition to grading of roads to serve these homesites, the creation of level pads for tract housing can add to initial energy input. In densely-vegetated areas of the site, clearance of trees and brush may also add to energy use. Clustering of units (see page 107) may be an effective way to reduce grading and clearance requirements.

Direct energy inputs for grading operations can be estimated by using the data in Table A-18. For large projects an average of 27,000 BTU's of fuel per cubic yard of grading would be required for moving dirt, and 45,000 BTU's of fuel per cubic yard would be needed in rocky areas. Fuel savings due to reduced site grading can be calculated from these figures, if the reduction in volume of grading is known.



C 1a MITIGATION MEASURE: To reduce energy input for grading and clearance, homesites may be shifted away from areas of steep slopes or dense vegetation. Existing healthy vegetation should be retained whenever possible.

APPLICABILITY: Subdivisions with development in areas of steep slopes or dense vegetation.

CONFLICTS: Elimination of lots in areas of steep slopes or dense vegetation may result in lower returns for the developer. Lots on steep slopes typically have better views and higher value than lots on level or clear sites.

BENEFITS: Preservation of existing trees on a building site has been shown to increase property value and aesthetic value of the site.

In cases where the existing trees are diseased, or where clearance is unavoidable, the use of cleared trees for firewood should be considered. A large tree may yield one cord of firewood or more. Heating values for hardwood average around 20 million BTU's per cord; with a typical fireplace efficiency of 25%, a large tree can be considered to represent 5 million BTU's of usable heat. Cutting and transportation of firewood would involve only a small percentage of this value.

C1b MITIGATION MEASURE: The net impact of site clearance may be reduced if the removed trees are used for firewood.

APPLICABILITY: Sites with trees suitable for firewood.

CONFLICTS: Extra work in clearance to cut up firewood.

BENEFITS: Possible financial benefits for developer.

Demolition of existing structures may require additional energy input. In many cases, existing buildings such as barns and farmhouse are still in sound structural condition. Use of such structures for community buildings can help to conserve energy, as well as providing a sense of cultural continuity and diversity in the project.

C1c MITIGATION MEASURE: Existing structures on the site may be incorporated into the development plan, eliminating energy requirements for demolition and reducing the need for construction of new facilities.

APPLICABILITY: Sites with existing usable structures.

CONFLICTS: Extra time and planning may be required for using existing buildings.

BENEFITS: Possible cultural benefits from preservation of historical buildings.

2. Storm Drainage

On most undeveloped sites, rainwater is absorbed by the soil or is taken off the site in natural drainage channels. However, building of streets in a new subdivision, as well as the subsequent construction of homes and driveways, greatly increases the amount of runoff from the site. A considerable input of energy is typically needed for construction of storm sewers and channels to avoid flood problems.

In many cases, existing natural drainage channels may still be adequate to handle most of this runoff. However, developers often will channelize these streams so that more lots can be fitted onto the site. As an alternative approach, adequate open space can be left along stream banks to allow for occasional overflow. In addition to conserving energy, this open space can provide recreational and other environmental benefits. A combination of a small underground conduit and modified natural channel may be an appropriate compromise in some situations.

C2a MITIGATION MEASURE: Initial energy input for construction of storm drainage facilities may be reduced by leaving open space corridors along natural drainage channels, so that existing streams can continue to remove runoff from the site.

In addition to reliance on natural drainage channels, other methods can be used to reduce runoff and thus decrease the energy input for storm sewers and channels. Where permeable soils are available on the site, water can be conducted to percolation basins, recharging underground aquifers.

C2b MITIGATION MEASURE: Percolation basins on the property may reduce the energy input for construction of storm drainage facilities.

Reduction of paved surfaces in a project can have multiple energy conservation benefits, described on page 118. The permeability of the paving can also have an effect on energy input, by reducing the need for construction of storm sewers. Various approaches, including porous pavement, use of "eco-blocks" with openings in a paved grid, and the use of gravel in parking areas, can reduce storm runoff.

C2c MITIGATION MEASURE: Permeable paved surfaces may be used to reduce energy input for storm drainage facilities by decreasing runoff from the site.

APPLICABILITY:

C-2a: Sites with existing defined drainage channels.

C-2b: Sites with permeable soils adaptable for percolation basins.

C-2c: All projects.

CONFLICTS: Maintenance costs and related energy requirements may be increased if natural drainage channels are used. Percolation basins take up room on the site, adding to dispersion of housing and decreasing developers' returns; they may have limited recreational value. Percolation basins and permeable pavement areas may require extra maintenance.

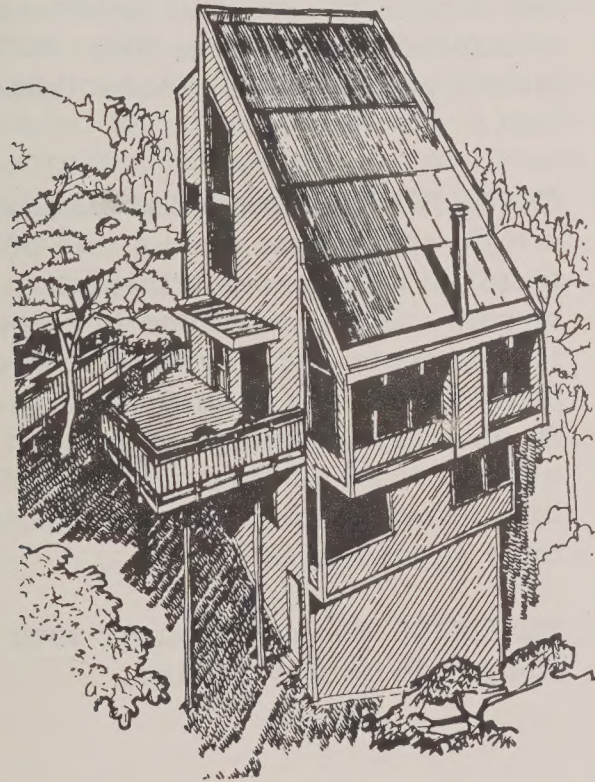
BENEFITS: Replenishment of ground water through aquifer recharge; recreational, aesthetic and other environmental values protected, if natural stream channels are retained.

3. Adaptation to microclimate

In evaluating the layout of a large project, consideration should be given to the differences in climate which exist on the site. These local variations may have a significant effect on long-term energy use for home heating and cooling. In this section those adaptations which would require redesign of the project are noted. Specific methods of microclimate modification, not requiring redesign of the project, are outlined on page 126.

The aspect of a slope, or the direction it is facing, affects the amount of sunlight reaching the homesite. In Contra Costa County, a south-facing slope generally has the most potential for energy-conserving development. This slope aspect increases the feasibility for using solar energy in space heating and water heating; in addition, less fuel is needed for heating in winter. This advantage may be partially offset by increased summer cooling needs in hot-summer areas of the county, although this problem generally can be avoided through proper home design. In comparison with south slopes, development on north slopes generally would require more fuel for heating. West slopes have unfavorable orientation to hot afternoon summer sun. East slopes are thus second in desirability to south slopes on most sites.

In addition to slope aspect, the location of development in relation to prevailing winds should be evaluated. Avoidance of cold winter winds, as well as access to welcome summer breezes, may be important. Exposed ridges and gaps with strong winter winds will add to heating fuel needs for housing in these locations. However, a sheltered location in hot-summer portions of the county may increase the need for air conditioning, aggravating peak-load demand for electricity.



- C3 MITIGATION MEASURE:** Long-term energy use for home heating and cooling may be reduced by locating development in favorable microclimatic areas of the site, including:
- a. South-facing slopes; avoidance of north-facing slopes;
 - b. Areas protected from cold winter winds; avoidance of exposed ridgetops and wind gaps;
 - c. Locations with access to summer breezes; avoiding overly-sheltered locations in hot-summer areas of the county.

APPLICABILITY: All projects with development proposed in areas of unfavorable solar or wind conditions.

CONFLICTS: Planning for microclimate benefits alone may conflict with other energy and environmental needs; a comprehensive review of all site and environmental conditions is needed.

BENEFITS: In addition to potential energy savings, comfort of residents may be improved by avoiding home-sites with strong winds or unfavorable sunlight conditions.

4. Planning for energy-conserving orientation of buildings

The orientation of homes can have a considerable effect on energy use for fuel used in cooling or heating the residence. Studies in Davis, California, have shown that maximum south window exposure, with proper shading devices, can achieve significant energy savings in that community. Similar benefits could be obtained in all Contra Costa County climate conditions, particularly in hot-summer areas.

While this need for proper orientation of buildings is discussed in more detail in Appendix C, the orientation of future buildings should also be considered at the time that a subdivision is laid out. In most subdivisions, particularly those with lots under an acre in size, there is a strong tendency to build the long axis of the house parallel to the street, with most of the windows also parallel to this axis. If the streets are running east and west, the home-builder will have the opportunity to place most windows on the south exposure. In this way, excessive heating from windows on the west or east walls can be minimized; with the use of deciduous trees and overhangs, the south windows can serve the dual function of admitting welcome winter sun while excluding hot summer sunlight. Also, this orientation would encourage the use of solar collectors for heating, since solar collectors operate most efficiently on south-facing roof slopes.

C4 MITIGATION MEASURE: To plan for energy-conserving orientation of future homes in a subdivision, the long axis of the lot (extending away from the street) should be oriented within 30° of a north-south line.

APPLICABILITY: Subdivisions with long dimensions of lots oriented more than 30° from a north-south axis. All county climate conditions: most important in hot summer areas. Not applicable to subdivisions with large lots, with minimum dimensions greater than 100 feet.

CONFLICTS: Without careful planning, a rigid application of this rule could result in monotonous grid-pattern streets. Some variations in setback requirements and curvature of streets could be used to minimize this problem. An economic conflict may arise if an east-west street layout would reduce the number of lots created or increase total street length.

BENEFITS: The potential for long-term energy savings is created.

5. Lot layout in relation to utilities

In a water system, pressure decreases with increasing elevation. Above a certain height, supplementary pumping of water may be necessary to serve homesites above this level. In addition to the electricity requirement for pumping, energy input may be needed for construction of additional storage tanks or reservoirs, and for maintenance of pumps and tanks.

Supplementary input may also be needed for sewage systems, which operate on gravity flow. If homesites are below the elevation of trunk sewer lines serving the area, electricity will be needed for pumping sewage up to the line. By avoiding homesites in areas where special pumping would be required, energy can be conserved.

C5 **MITIGATION MEASURE:** To reduce electrical energy use for pumping, and to avoid additional energy input for construction and maintenance, homesites in locations requiring supplementary pumping of water or sewage may be relocated or eliminated.

APPLICABILITY: Projects with homesites above critical elevations for water pressure, or homesites below critical elevations for gravity flow of sewage.

CONFLICTS: Possible economic loss to developer if lots must be eliminated.

BENEFITS: Energy savings and elimination of possible "problem spots" in water and sewer systems; greater reliability of service in case of power failure.

D. SITE PLAN: INTERNAL CIRCULATION

In addition to regional energy issues related to site location, described on pages 102-106, the specific layout of circulation routes within the subdivision can have an important effect on energy use. An energy-conserving circulation system within the subdivision can reduce initial energy input for construction, as well as diminish long-term vehicular fuel consumption.

1. Street and utility line lengths

As noted previously, initial energy input for a subdivision is directly related to the total length of streets. Any measure to reduce the amount of streets, while still providing satisfactory circulation in a subdivision, is an important way to conserve energy. This advantage can be canceled out, however, if long, circuitous routes are needed to reach lots; direct traffic patterns are needed.

When used properly, cul-de-sacs can serve as an important means of reducing street lengths. In place of a pattern where all streets are continuous, cul-de-sacs can feed traffic onto collector streets. The lack of through-traffic on cul-de-sacs also makes these streets safer for children.

In most cases, length of utility lines is directly related to street length, so that shorter streets also mean less energy expenditure for placement

of utility lines. In some cases, however, independent energy savings may be obtained by redesigning the utility system to provide more efficient service.

An estimate of the energy benefits obtained by reducing street lengths can be calculated using the information in Table 1.5.

D1 MITIGATION MEASURE: To reduce construction energy input and long-term fuel use for vehicles, street and utility line lengths may be kept to the minimum needed to provide satisfactory circulation within the subdivision.

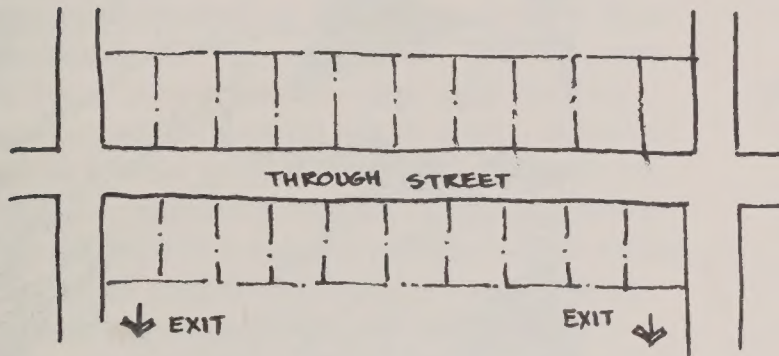
APPLICABILITY: Projects with inefficient layout of streets and utility lines.

CONFLICTS: Unless circulation patterns are carefully considered, the short-term energy advantages of minimum street lengths could be canceled out by long-term energy waste due to excessive driving. Convenience for residents could also be hampered by awkward street patterns where minimum length is the only criterion.

BENEFITS: Minimum street lengths provide an obvious financial benefit to the developer, which can be passed on to the homebuyer. The extra space created by eliminating excessive streets can be used for recreation.

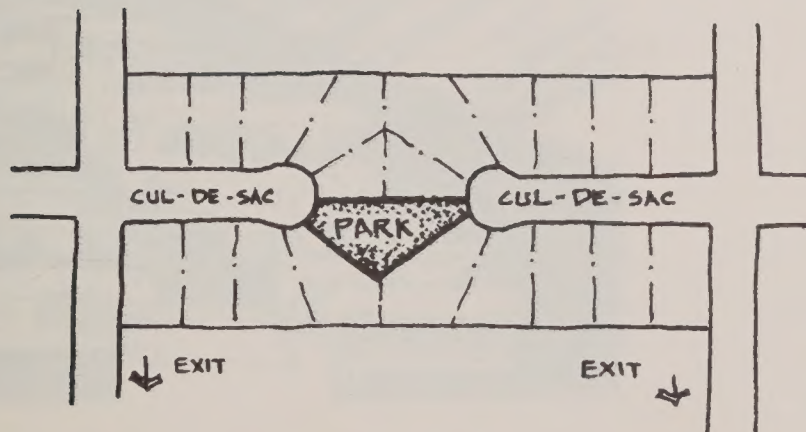
EXAMPLE: In place of a through-street, adjoining cul-de-sacs may be connected with bicycle and pedestrian links. The

space between cul-de-sacs is ideal for a small park or tot lot, which can serve as a focus of neighborhood activity.



THROUGH STREET

20 lots @ 10,000 sq. ft.
1600 lin. ft. street



CUL-DE-SAC

20 lots @ 10,000 sq. ft.
1350 lin. ft. street
Amenities: 12,000 sq. ft. park.

2. Favorable traffic flow conditions

In evaluating the circulation system in a subdivision, the need for convenient traffic circulation must be kept in mind. Cul-de-sacs and local streets should feed into collector streets, in a circulation system design to keep travel distances to a reasonable minimum. The collector streets should also route traffic in the direction of most traffic generators.

While minimum street lengths should usually result in minimum travel distances, this is not always the case. Improperly-designed subdivisions without adequate collector streets may result in excessive driving, which could cancel out any short-term energy benefits of minimum street construction.

D2 MITIGATION MEASURE: To reduce long-term fuel use for vehicles, the street layout may be redesigned to provide more direct traffic flow.

APPLICABILITY: All projects.

CONFLICTS: This measure may conflict with the need to keep street lengths to a minimum. Additional street construction for favorable traffic flow may add to the initial energy input and economic cost of the project.

BENEFITS: Potential long-term energy savings, and increased convenience for residents.



3. Street widths

In the County's subdivision standards, minimum widths for various street classifications have been established. These regulations have been based on the need for smooth traffic flow as well as emergency access requirements for fire trucks. In some cases, however, these needs may be satisfied by narrower streets than those now required. In particular, cul-de-sacs and other local streets with very light traffic could be reduced to a width of 26 feet, allowing two lanes of traffic with parking on one side of the street. Local street widths could be further reduced to 20 feet if frequent parking bays would be provided. In addition to minimizing energy input for paving, these reduced street widths could reduce the problem of heat build-up in hot-summer areas (see page 126).

D3

MITIGATION MEASURE: To reduce initial energy input for paving, as well as long-term effect due to summer heat build-up on paved surfaces, street width requirements could be reduced in new subdivisions.

APPLICABILITY: Initial energy benefits in all project. Long-term benefits due to reduced street widths would apply only in hot-summer areas.

CONFLICTS: Possible increased traffic hazards on narrow streets; inconvenience to residents if restrictions on parking are imposed; potential difficulties for emergency vehicle access unless parking restrictions are adequately enforced.

BENEFITS: Savings to the developer for site improvements, which could be passed along to lot buyers.

4. Non-motorized circulation

In reducing the dependence on the private automobile for travel, subdivisions can be designed to encourage walking and bicycling. While extra energy input may be needed to construct sidewalks and bike paths, the long-term energy savings should outweigh this initial expenditure.

a. Bicycle routes. The multiple advantages of bicycling to conserve energy, reduce air pollution and provide exercise are well-known. It is important to plan for bicycle use at the time of subdivision design, since good design of bikeways can increase the attractiveness of bicycling as an alternative to the automobile. Bicycle paths planned in conjunction with linear parks in a subdivision can be particularly advantageous, since safety hazards can be reduced by separating bicycles from heavy automobile traffic. Short links can connect designated bikeways along subdivision cul-de-sacs with light traffic (see sketch, page 119).

Two basic points should be kept in mind when planning a system of bikeways in a new subdivision. First, the most direct paths to common destinations in the neighborhood (particularly schools) should be chosen; bicyclists will not go far out of their way to use a designated path. Second, the internal bike-path system within the subdivision should tie in with the surrounding area. Safety hazards can result if bikeways stop abruptly

at the edge of a project, forcing bicyclists to compete on heavily-traveled streets. Ideally, the on-site bicycle routes should tie into a comprehensive system of bike trails extending throughout an urban area.

D4a MITIGATION MEASURE: To reduce automobile use, bikeways may be provided in new subdivisions.

APPLICABILITY: All climate zones, although bicycling may be less desirable in areas with strong winds or rugged terrain.

CONFLICTS: Safety hazards can be created in incomplete or badly-planned bicycle systems, although well-designed bike routes should reduce traffic hazards. Construction of bike paths may add to the developer's cost, and increase the initial energy input, but long-term energy savings and recreational benefits should outweigh this disadvantage. Noise problems might result if bike paths along rear lot lines would be used by motorcyclists; regulations and adequate policing could minimize this problem.

BENEFITS: In addition to long-term energy savings, bicycling can reduce air pollution and provide health benefits.

b. Pedestrian circulation. Sidewalks are now required by the County for most residential development. However, in projects with lots larger than 12,000 square feet, sidewalks often are not required except along lines of direct access to schools. Pedestrian circulation in these areas would be discouraged, since people would have to walk in the street. For low-density residential development, sidewalks are still needed, although a walk on one side of the street should be sufficient, and the standard four-foot width might be reduced. In semi-rural locations, an unpaved bridle trail along the road may be appropriate. Where possible, linear parks with pedestrian paths could be provided to increase the attractiveness of walking to local destinations. Bike paths and pedestrian paths could follow the same route if a separate lane is designated for bicycles.

D4b

MITIGATION MEASURE: Sidewalks and pedestrian paths may be provided in new subdivisions to reduce dependence on the automobile.

APPLICABILITY: All projects.

CONFLICTS: Sidewalk requirements in low-density residential areas (where they are not now required) would add to developers' costs and initial energy input; long-term benefits should outweigh these disadvantages. Reduced standards (one side of street, reduced widths) can also lessen this problem.

BENEFITS: In addition to long-term energy savings, use of pedestrian walkways can reduce air pollution and provide health benefits.

E. DETAILED DESIGN CONSIDERATIONS

In this section, various energy conservation problems and possible solutions are discussed for detailed site improvements. While earlier suggestions involved alternate locations, design concepts or major redesigns, the mitigation measures in this section usually may be applied without altering the developer's preliminary site plan. At the same time, however, the basic information needed for review (type of street lighting, for example) may be unavailable at the time of environmental impact report preparation. If this is the case, suggestions may still be made for inclusion in the final development plan or conditions set by the County.

1. Selection of materials

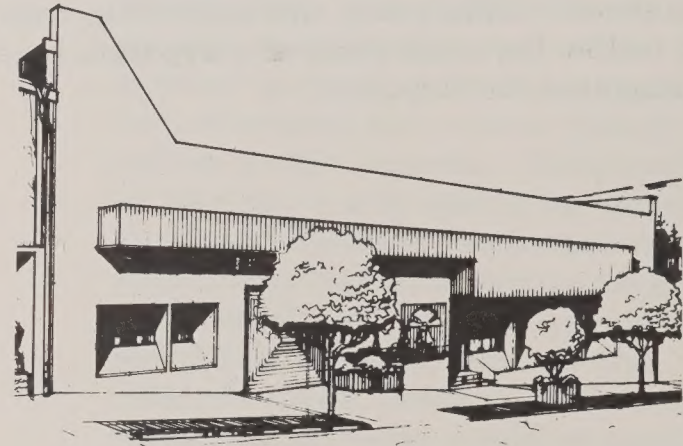
As noted in Chapter 1, some materials are "energy-intensive," requiring large amounts of fuel for production. As a general rule, locally-available materials and products requiring a minimum of processing, such as wood and local stone, are more energy-efficient than cement, asphalt, metals and plastics requiring intensive energy input. This point should be kept in mind when selecting materials for signs, lighting standards, and other initial improvements. Durability of materials must also be considered; "energy-efficient" materials requiring frequent replacement may not be a long-term energy bargain.

E1 MITIGATION MEASURE: Use of energy-efficient building materials for initial site improvements may reduce the total energy impact of the project.

APPLICABILITY: All projects.

CONFLICTS: Limitation of individual choice in material selection.

BENEFITS: Energy-efficient building materials usually cost less.



2. Street lighting

Electricity for street lighting in Contra Costa County comprises a significant percentage of total electricity use in the county. In evaluating standards for street lighting, public safety requirements must be weighed against the need for energy conservation. At present, street lighting requirements in the county are about 60% of the nationally-recognized Illuminating Engineering Society Standards¹. In general, the County provides 175 lumen watt lamps every 250 feet, whereas most cities provide one every 175 feet. Administration officials have encountered no problems in using these reduced lighting levels, and their continued application can help in conserving electrical energy.

As a further means of conserving energy, high-intensity discharge (HID) lamps may be used in street lighting. Made of high-pressure sodium and metal halides, these lamps provide more lumens per watt than conventional street lighting.

¹Illuminating Engineering Society, Illuminating Engineering Society Handbook, John E. Kaufman, ed. (New York: Illuminating Engineering Society), Figure 20.4.

E2 MITIGATION MEASURE: To decrease construction energy input and long-term electricity use, reduced standards for street lighting may be maintained. High-intensity discharge lamps may be used to obtain energy-efficient illumination.

APPLICABILITY: All projects.

CONFLICTS: Reduced street lighting must be balanced against public safety needs. H.I.D. lamps are initially more expensive than conventional lighting.

BENEFITS: Reduced street lighting requirements can result in reduced costs to developer, and long-term energy savings.

3. Microclimate modification

The initial construction of subdivision streets, as well as the subsequent building of homes and driveways, can have a significant influence on microclimate. On an undeveloped site, natural vegetation or crops can have a cooling effect in summer, due to transpiration and shading. In contrast, the paved surfaces and roofs in a developed subdivision may absorb considerable solar radiation and contribute to heat build-up on the site. In cool-summer areas, this heat build-up may have little adverse effect on energy use, and may even have a beneficial impact when winter heat build-up benefits are taken into account. In hot-summer areas of the county, however, unshaded paved surfaces may create "urban desert" conditions, leading to increased demands for electricity to run air conditioners. Increased electricity demand during this period may be critical, since "peak load" conditions often occur during hot summer days due to air conditioning requirements. A rise of even a single degree in ambient temperature during these periods may strain utility capacity.

To reduce adverse energy impact due to heat build-up on paved surfaces, three basic approaches can be used. The area of paving can be reduced; shading of paved surfaces can be provided; and water surfaces can be used to cool ambient air temperatures.

a. Lot coverage restrictions. At the time of subdivision, regulations governing the amount of paved surface on each lot could be established. Lot coverage restrictions are already in common use for building coverage on a site, but overall coverage of paved surfaces is not usually controlled. Incentives could be included for using sod roofs, roof gardens, arbors, shade trees, or other methods of reducing unshaded paved surface area.

E3a MITIGATION MEASURE: Lot coverage restrictions, regulating unshaded paved surfaces, could be used to reduce peak-load electricity use for air conditioning due to summer heat build-up.

APPLICABILITY: Hot-summer areas of the County.

CONFLICTS: Restriction on individual use of property.

BENEFITS: Control of paved surfaces can benefit neighborhood appearance as well as provide energy savings.

b. Street trees. As a condition of subdivision approval, street trees may be required to shade the pavement. These trees should preferably be deciduous so that welcome winter sunlight will be available. Large trees have the advantage of maximum shading at maturity; small trees, such as flowering cherries, might be ineffective in shading paved surfaces. Spacing of trees should also be considered; the common use of one street tree per lot usually results in ineffective shading, and spacing of trees at 30' intervals or less would provide more protection against summer heat build-up.

E3b MITIGATION MEASURE: Street trees may be required as a means of reducing energy consumption problems due to summer heat build-up on unshaded surfaces.

APPLICABILITY: Hot-summer areas of the County.

CONFLICTS: Minor additional cost to developer.

BENEFITS: Improved appearance of street, which has been shown to improve property value.

c. Windbreaks. Strong winter winds on the site could lead to increased energy use for heating of future homes on the site. To shelter exposed homesites from prevailing winter winds, the developer could plant windbreaks on the property. Careful planning would be needed, however, to integrate windbreaks into the landscape; clustering of trees in strategic locations may be preferable to long, straight lines of trees.

E3c MITIGATION MEASURE: To reduce long-term fuel use for home heating, windbreaks could be planted on the site to shelter homesites exposed to strong winter winds.

APPLICABILITY: Sites with strong winter winds.

CONFLICTS: Extra cost to developer; possible aesthetic problems if long windbreaks are planted on exposed ridges.

BENEFITS: Long-term energy savings; possible aesthetic benefits with sensitive planning of windbreaks.

d. Use of water areas. In planning open-space areas of subdivisions, the advantages of water surfaces in modifying climate should be considered. Location of lots near water can help to reduce summer heat build-up problems; large water bodies can create cool summer breezes, reducing the need for summer air conditioning. However, a significant cooling effect generally is achieved only within a short distance away from the water surface. As a general rule, climate is moderated significantly for a distance of one-twentieth of the width of the water body, on the downwind side of the water surface.

E3d MITIGATION MEASURE: Water surfaces may be used to moderate hot summer temperatures and reduce the need to use electricity for air conditioning.

APPLICABILITY: Hot-summer areas of the County.

CONFLICTS: Water needed for artificial lakes may aggravate water shortages. The energy input for this additional water supply may outweigh the energy benefits obtained by reduction of air conditioning.

BENEFITS: Possible aesthetic and recreational benefits.

e. Landscaping and structures on individual lots. Specific landscaping on private lots usually is not determined at the time of subdivision approval, but is left to the individual lot buyer. However, developers may provide landscaping advice or plants to lot buyers. The selection of landscape plants may have a significant long-term effect on energy use for home heating and cooling. In addition, guidance on orientation, window location and general building design can help lot buyers to plan energy-conserving homes. (If the land subdivider also plans to build homes on the lots, guidelines for this future construction also may be established at the time of subdivision approval. Specific references on energy conservation through the use of landscaping and building design are outlined in Chapter 4.) The use of an energy conservation booklet, with the subdivider then providing appropriate plants for lot buyers, could be a particularly effective way to achieve long-term energy benefits.

E3e MITIGATION MEASURE: To reduce long-term energy use for home heating and cooling, guidelines for landscaping and building design on individual lots may be established at the time of subdivision approval; suitable plants and conservation booklets also could be furnished by the developer to lot buyers.

APPLICABILITY: All subdivisions where individual lot treatment is left to lot buyers.

CONFLICTS: Additional cost to developer for publishing and distributing guidelines, and for landscape plants furnished to lot buyers.

BENEFITS: Potential aesthetic advantages as well as long-term energy savings.

4. Landscape establishment and maintenance in open-space areas

The type of landscaping in open-space areas can have a significant effect on initial and long-term energy consumption for maintenance. Direct energy input may be needed for site preparation, lawn mowing and chemical application; indirect energy may include energy for production of fertilizer, pesticides, and water supply. Comparative energy inputs for landscaping are indicated in Table A-20, page 203.

A basic rule can be followed to reduce energy demands of landscaping: plants adapted to local site and climate conditions should be used whenever possible. If landscaping is poorly adapted to the site, energy will be needed to create artificial conditions necessary for plant growth, including irrigation, pesticide application and soil treatment.

Based on this principle, lawn areas should be kept to the minimum necessary for recreational needs. Due to their need for frequent mowing, and indirect energy input for irrigation, herbicides and pesticides, lawns are energy-intensive in comparison with shrubs or groundcover (see Table A-20, page 203). Drought-resistant, low-maintenance plantings should be used whenever possible, since minimum energy input would be needed.

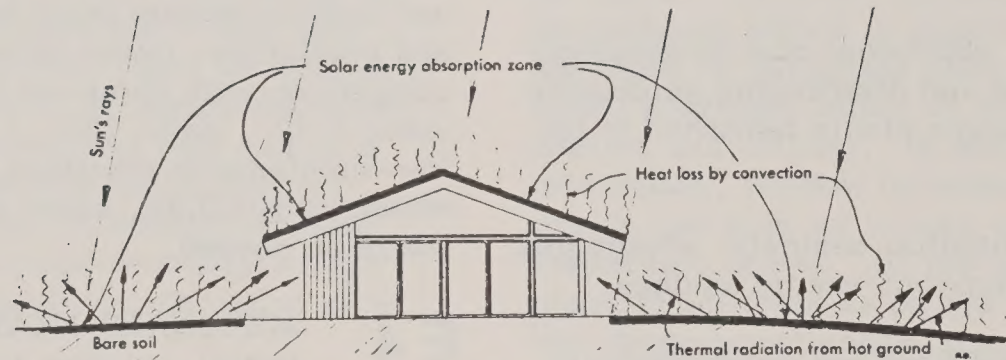
E 4

MITIGATION MEASURE: To reduce initial and long-term energy input for establishment and maintenance, landscape plantings adapted to site and climate conditions may be used.

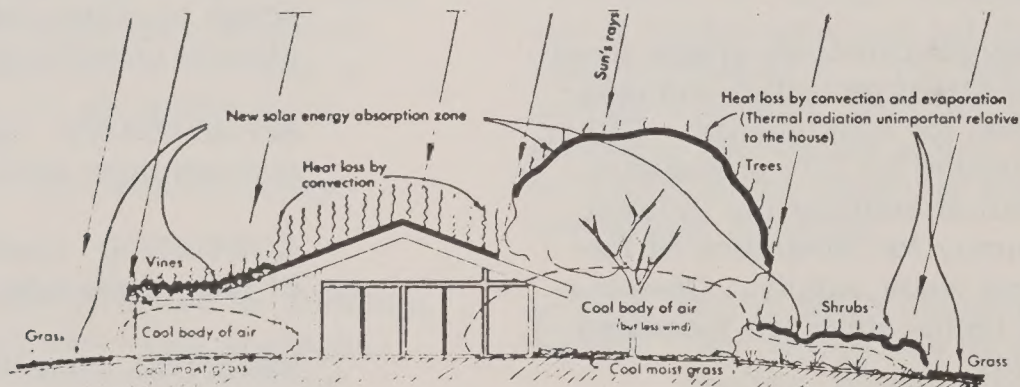
APPLICABILITY: All projects with common open space.

CONFLICTS: Limitations on choice of plant materials.

BENEFITS: Long-term savings of money, water resources and energy.



Typical situation before planting or site without trees.



As soon as a bare surface is covered with vegetation, the heat absorbing surface which was previously held by the soil and roof is then transferred to the upper layers of foliage, in trees, shrubs, vines and turf, and a cool body of air is then produced by evaporation in the shade.

F. USE OF DECENTRALIZED OR RENEWABLE ENERGY SOURCES

To conserve non-renewable fossil fuels, alternative sources such as solar energy, wind power and biofuels can be considered. Food is also a form of fuel, and decentralized methods of food production can conserve energy.

Subdivision of land is an early stage in the development process, and use of renewable energy sources is usually not considered until actual building construction takes place. It is important, however, to set the stage for long-term use of alternative energy sources, establishing incentives while avoiding regulations which could inhibit the use of decentralized or renewable energy sources.

In addition to governmental regulations, many developers provide deed restrictions which control various aspects of private development on homesites. These regulations generally are intended to provide an attractive neighborhood appearance and protect property values. However, the use of renewable energy sources may be inhibited if these deed restrictions are inflexible.

1. Solar energy

a. Solar zoning. In addition to conventional zoning regulations, there has recently been an increasing recognition of the need to protect a landowner's right to sunlight on his property. Large trees or structures on adjoining property could cast shade on a homesite, eliminating the possible use of solar energy for heating.

The City of Davis, California, has been a pioneer in considering "envelope zoning" regulations which limit the placement of trees or buildings which could shade adjacent property. By establishing these regulations at the time of subdivision approval, potential handicaps in the future use of solar energy are avoided.

F1a

MITIGATION MEASURE: To plan for potential use of solar energy on homesites, solar zoning regulations which guarantee a property owner's access to sunlight may be adopted.

APPLICABILITY: All projects.

CONFLICTS: Restriction on private use of land.

BENEFITS: Potential long-term energy savings.

b. Roof treatment. In some subdivisions, a standard roof treatment (such as wood shakes) is specified in the deed restrictions. Unless this requirement is flexible, the use of solar collectors on roofs may be precluded.

F 1b MITIGATION MEASURE: If deed restrictions specify a standard roof treatment, flexibility in this requirement may be needed to allow the use of solar collectors on roofs.

APPLICABILITY: Projects with deed restrictions specifying a standard roof treatment.

CONFLICTS: Possible aesthetic objections.

BENEFITS: Potential long-term reduction in use of non-renewable fuels.

c. Clotheslines. In some projects, deed restrictions may prohibit clotheslines. More flexible regulations which control rather than prohibit clotheslines may aid in the use of solar energy for clothes drying.

F 1c MITIGATION MEASURE: To allow the use of solar energy for clothes drying, deed restrictions could permit the use of clotheslines.

APPLICABILITY: Projects where clotheslines would be prohibited by proposed deed restrictions.

CONFLICTS: Possible aesthetic conflicts.

BENEFITS: Potential energy benefits from reduced use of mechanical clothes dryers.

2. Wind power

The use of wind for generating electricity is feasible only where strong, dependable winds are present. Windmills requiring lower wind velocity may also be used for water pumping in some subdivisions. However, severe limitations on height of structures could hinder the use of wind power.

F 2 MITIGATION MEASURE: Windmills could be used to generate electricity or pump water, provided that height regulations are sufficiently flexible to allow the use of towers for wind generators.

APPLICABILITY: Sites with strong, dependable wind conditions, or projects where on-site water pumping may be required.

CONFLICTS: Possible aesthetic objections to wind generators.

BENEFITS: Potential long-term reduction of non-renewable fuel consumption.

3. Methane

The generation of methane from domestic sewage is a possible alternative source of energy in residential projects. On-site waste disposal systems could be used to provide compost as well as generate methane, while reducing demand on centralized sewage treatment plants. However, health regulations may prohibit the use of these on-site waste disposal systems.

F 3 MITIGATION MEASURE: On-site generation of methane from domestic sewage could reduce demand for fossil fuels, provided that health regulations are sufficiently flexible to allow on-site waste disposal systems.

APPLICABILITY: All projects.

CONSTRAINTS: Possible health or aesthetic problems.

BENEFITS: Potential long-term reduction of non-renewable fuel consumption.

4. Wood

As previously noted on page 112 , the use of trees cleared from the site for firewood can provide a renewable source of fuel. Establishment of managed woodlots, as a part of large projects, also could provide a long-term renewable fuel source.

F4 MITIGATION MEASURE: Firewood obtained from cleared trees or managed woodlots could provide an alternative source of energy.

APPLICABILITY: Projects including clearance of trees, or large subdivisions with sufficient open space for managed woodlots.

CONFLICTS: Possible conflicts in use of open space.

BENEFITS: Potential long-term reduction in use of non-renewable fuels.



5. Urban agriculture

Methods of commercial food production and distribution in modern society have become energy-intensive, due to the concentrated use of equipment, fertilizer, chemicals and wide-spread distribution systems. In contrast, home gardening and raising animals for food may be very energy-efficient; energy for distribution is eliminated, and fuel for power equipment may be largely replaced by human labor (providing exercise for urban residents as well).

a. Gardening. The layout of subdivisions may help in determining whether residents will take advantage of energy-conserving home food production. In developments where multi-family housing is planned, residents may not have an opportunity for gardening unless common areas are provided for this purpose. In clustered single-family developments, small private outdoor space may be inadequate for gardening.

F5a **MITIGATION MEASURE:** In subdivisions with planned multi-family development, adequate common open space could be reserved to provide future residents with the opportunity for gardening.

APPLICABILITY: Subdivisions where multiple-family housing would be included.

CONFLICTS: Possible aesthetic or recreational conflicts in open-space areas.

BENEFITS: Potential for long-term energy savings; increased individual opportunity for gardening.

b. Raising of animals for food. Zoning regulations or deed restrictions typically have severe restrictions on keeping of livestock in residential areas. While these regulations may help to avoid problems of odors or noise, more flexibility may be needed in allowing the raising of small animals for food. Often pets are allowed in residential areas while other animals of a similar size and disposition are prohibited.

F5b MITIGATION MEASURE: To provide maximum possible energy benefits from urban agriculture, restrictions on animal raising in residential neighborhoods could be kept to a minimum consistent with aesthetic values.

APPLICABILITY: All projects.

CONFLICTS: Possible aesthetic problems if keeping of animals is not carefully regulated.

BENEFITS: Increased individual freedom for residents; possible long-term energy benefits.

G. SUMMARY

After reviewing the various mitigation measures and alternatives to reduce the long-term energy consumption of the project, it may be that serious and unavoidable adverse energy impact would still result from approval of the subdivision. The question of need for the project should be carefully considered; intensive demand for housing could lead to later approval of a subdivision with much higher energy input per unit. In discussing the "no project" alternative, the comparison of existing and proposed energy use (see page 99) should be noted; even if the project were denied, substantial energy use on the site might continue in some cases.

G1 ALTERNATIVE: No project.

APPLICABILITY: All projects.

CONFLICTS: Possible contribution to housing shortages.

BENEFITS: Long-term energy savings.

Phase 4 : Presentation of Information

The procedure outlined in Chapter 2, pages 61-63, can be followed in preparing the E.I.R. energy component for a subdivision. A sample outline of an energy component is included on page 64.



TABLE 3.8

ENERGY EVALUATION CHECKLIST: PROPOSED SUBDIVISIONS

ENERGY CONSERVATION PROBLEM	MANUAL PAGE	POSSIBLE MITIGATION MEASURE (M) OR ALTERNATIVE (A)	A	M	CROSS- REFERENCE
A. <u>SITE LOCATION IN REGIONAL CONTEXT</u>					
A project site remote from existing services and facilities may result in:	103	A-1. Choose alternate site with convenient access to services and facilities.	A		G-1.
(a) excessive fuel consumption for access to site;	105	A-2. Self-contained development: provide necessary services and facilities on site.		M	F-1,2,3,4,5.
(b) fuel consumption for utility line construction;	106	A-3. Provide mass transit.		M	
(c) transmission line loss for utilities.					
B. <u>DEVELOPMENT CONCEPT</u>					
A conventional subdivision may not be energy-efficient due to:	108	B-1. Clustering of lots for detached homes.	A		C-1,2,3,4,5.
(a) dependence on the automobile in low-density development;	109	B-2. "Zero lot line" regulations or other reduced setbacks.		M	D-1,2; F-5; G-1.
(b) inefficient layout of streets and utilities;	110	B-3. Higher-density development.	A		F-5.
(c) lack of consideration for existing site conditions.					
C. <u>SITE PLAN: LOT LAYOUT</u>					
1. <u>GRADING AND CLEARANCE</u>					
Avoidable operation of equipment for grading, demolition or clearance in areas of steep slopes, dense vegetation or existing structures.	112	C-1a. Revise lot layout to reduce grading and clearance.	A		A-1; B-1; G-1.
	112	C-1b. Use cleared trees for firewood.		M	F-4.
	112	C-1c. Revise development plan to make use of existing structures.		M	

ENERGY CONSERVATION PROBLEM	MANUAL PAGE	POSSIBLE MITIGATION MEASURE (M) OR ALTERNATIVE (A)	A	M	CROSS- REFERENCE
2. STORM DRAINAGE Avoidable operation of equipment and use of energy-intensive materials for stream channelization and other storm drainage improvements.	113	C-2a. Provide open space to allow the use of natural drainage channels.		M	B-1; D-1.
	113	C-2b. Reduce runoff through the use of on-site percolation basins.		M	
	113	C-2c. Use permeable paved surfaces.		M	
3. ADAPTATION TO EXISTING MICROCLIMATE Inefficient home heating/cooling due to lots located in unfavorable microclimatic areas.	115	C-3. Relocate homesites in more favorable microclimatic areas on property: (a) south-facing slopes; (b) areas protected from winter winds; (c) locations with access to summer breezes.		M	A-1; B-1; E-3; G-1.
4. LOT ORIENTATION Inefficient home heating/cooling due to east-west lot orientation.	116	C-4. Re-orient lots to north-south axis.		M	B-1.
5. RELATION TO UTILITIES Supplementary electricity for pumping of water and sewage may be required for some homesites.	117	C-5. Eliminate or relocate homesites requiring special pumping for water and sewage.		M	A-1; B-1; G-1.
D. SITE PLAN: INTERNAL CIRCULATION					
1. STREET AND UTILITY LINE LENGTHS Avoidable energy use for construction of streets and utilities, due to inefficient subdivision layout.	118	D-1. Reduce lengths of streets and utility lines.		M	A-1; B-1; D-2.
2. TRAFFIC FLOW Inefficient automobile use due to unfavorable traffic flow.	120	D-2. Redesign street layout to provide more favorable traffic flow.		M	B-1; C-4; D-1.

ENERGY CONSERVATION PROBLEM	MANUAL PAGE	POSSIBLE MITIGATION MEASURE (M) OR ALTERNATIVE (A)	A	M	CROSS- REFERENCE
3. STREET WIDTHS Avoidable construction energy input, and possible impact from summer heat build-up, due to street widths in excess of traffic needs.	121	D-3. Reduce street widths.		M	E-3.
4. NON-MOTORIZED CIRCULATION Dependence on motorized transit due to lack of alternatives.	122	D-4a. Provide bicycle paths.		M	A-2; B-1.
	123	D-4b. Provide sidewalks.		M	A-2; B-1.
E. <u>DETAILED SITE ALTERATIONS</u>					
1. SELECTION OF MATERIALS Avoidable use of energy-intensive construction materials.	124	E-1. Use energy-efficient building materials.		M	
2. STREET LIGHTING Construction energy input and electricity for operation of street lights.	125	E-2. Maintain reduced street lighting standards where consistent with public safety, and use high-efficiency lamps for street lighting.		M	D-1.
3. MICROCLIMATE MODIFICATION Increased demand for electricity at peak load conditions for air conditioning, due to summer heat build-up from unshaded paved surfaces (hot-summer areas only); increased use of heating fuel due to strong winter winds.	126	E-3a. Impose lot coverage restrictions for unshaded paved surfaces.		M	D-1, D-3.
	127	E-3b. Plant street trees.		M	
	127	E-3c. Provide windbreaks.		M	C-3.
	128	E-3d. Use water areas for climate moderation.		M	
			E-3e. Provide manual for lot buyers on proper orientation and landscaping.		M
4. LANDSCAPE MAINTENANCE Avoidable equipment operation for lawn-mowing and other intensive maintenance of common areas; energy input for irrigation.	129	E-4. Keep lawn areas to a minimum and select low-maintenance, climate-adapted plantings.		M	

ENERGY CONSERVATION PROBLEM	MANUAL PAGE	POSSIBLE MITIGATION MEASURE (M) OR ALTERNATIVE (A)	A	M	CROSS- REFERENCE
F. <u>USE OF DECENTRALIZED OR RENEWABLE ENERGY SOURCES</u> 1. SOLAR ENERGY (a) Shading from neighbor's structures or trees may rule out the use of solar energy for heating. (b) Standardized roof treatment may preclude the use of solar collectors on roofs. (c) Clothesline prohibition in deed restrictions may lead to greater reliance on mechanical clothes dryers.	131 132 132	F-1a. Adopt solar zoning regulations. F-1b. Provide flexibility in roof treatment requirements. F-1c. Avoid prohibitions on clotheslines.		M M M	
2. WIND POWER Severe limitations on height of structures could hinder the use of wind power.	133	F-2. Provide flexibility in height regulations to allow towers for wind generation.		M	
3. METHANE Health regulations may prohibit the use of on-site waste disposal systems for methane generation.	133	F-3. Provide flexibility in health regulations to allow on-site waste disposal systems.		M	
4. WOOD Potential energy benefits from managed woodlots may not be considered.	134	F-4. Include managed woodlots in open space areas.		M	
5. URBAN AGRICULTURE (a) Energy-conserving garden plots may not be provided for residents in clustered or multi-family development. (b) Regulations may unduly restrict raising of animals for food.	135 136	F-5a. Provide areas for gardening in common open space. F-5b. Reduce restrictions on animal raising in residential neighborhoods.		M M	B-1, B-3. B-1, B-3.

ENERGY CONSERVATION PROBLEM	MANUAL PAGE	POSSIBLE MITIGATION MEASURE (M) OR ALTERNATIVE (A)	A	M	CROSS- REFERENCE
G. <u>SUMMARY</u> Serious and unavoidable adverse energy impact would result from project.	136	G-1. No project.	A		A-1; B-1; C-1,3,5.

CHAPTER 3: CASE STUDY

ENERGY COMPONENT
OF
ENVIRONMENTAL IMPACT REPORT

SHAPELL SUBDIVISION #4820
SAN RAMON, CALIFORNIA

INTRODUCTION

In recognition of the need to plan for energy-conserving development, the State of California requires that new projects should be evaluated to determine their effect on energy resources, with an identification of ways to reduce wasteful consumption of fossil fuels. This report is intended to meet this requirement, within the guidelines for E.I.R. preparation established by the State government.

In evaluating the energy impact of this subdivision, it is important to keep the total energy picture in mind. In addition to the direct energy use for construction of site improvements, the indirect energy input for production of materials must be kept in mind. Since the subdivision of land represents a clear commitment to residential development on the property, the long-term impacts of residential energy use must also be evaluated.

PROJECT AND SITE CHARACTERISTICS RELATED TO ENERGY USE

The Shapell Subdivision site is a 119-acre parcel located adjacent to and east of Interstate 680, south of the General Electric industrial site and north of Montevideo Road in San Ramon. The project would include 347 lots for single-family detached housing, as well as a ten-acre school site.

Energy-consuming processes

(a) Initial site clearance and construction of streets, a storm drainage channel, and other utilities, requiring gasoline and diesel oil for vehicular access to the site and for operation of equipment. Indirect energy inputs for fuel and materials would also be required.

(b) The creation of building lots would be followed by construction of homes on the lots, with energy input for access to the site and for operation of construction equipment.

(c) Similar inputs of energy would be required for construction of an elementary school to serve the subdivision residents and adjoining area.

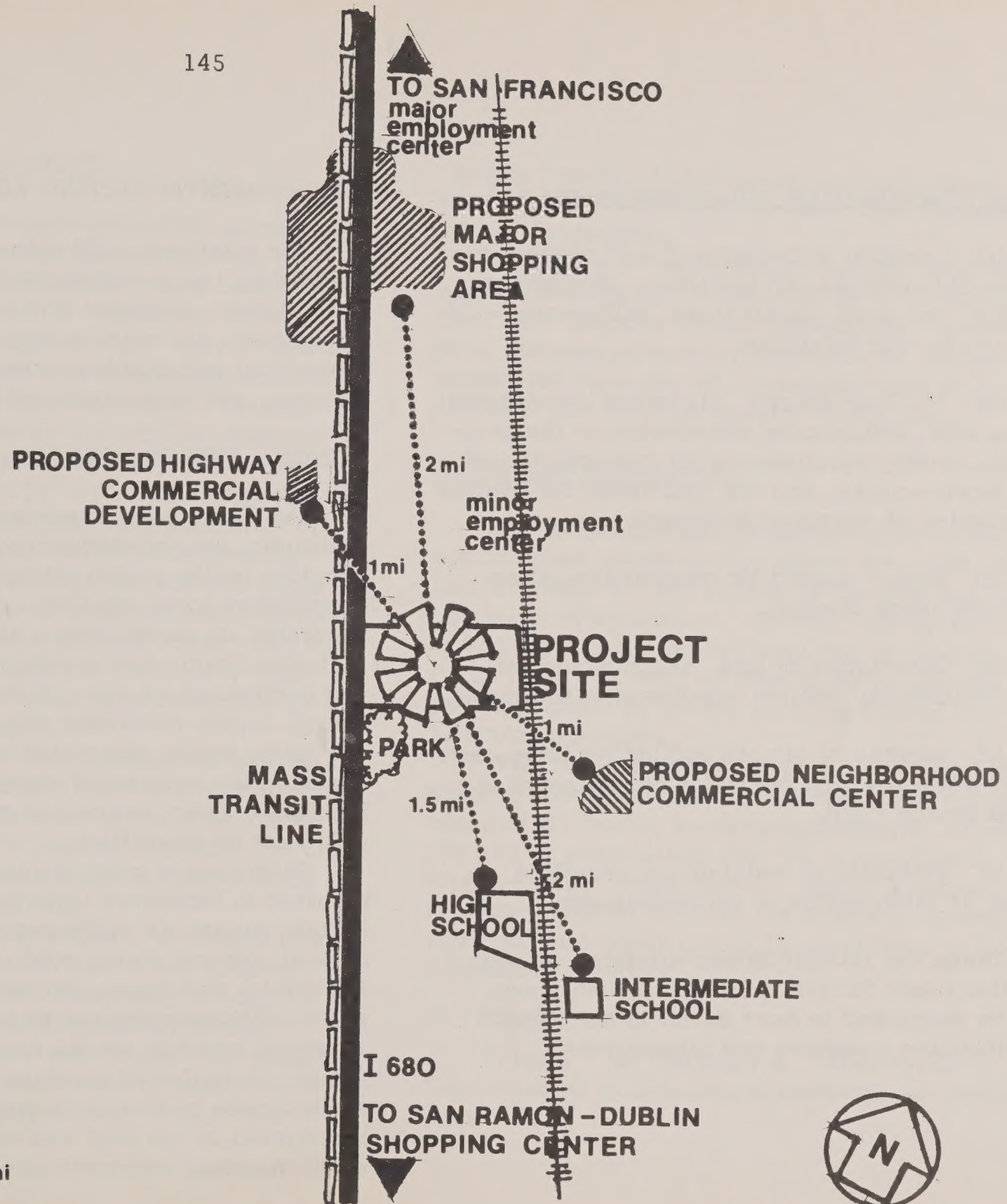
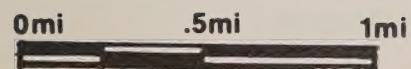
(d) Long-term energy input would be required for operation of housing and ancillary development, including fuel for heating and cooling, electricity for lighting and power, and motor fuel for access to the site.

Energy conservation measures and standards

No statement of proposed energy conservation measures has been submitted by the developer. Future homes in the subdivision would be required to meet established state energy conservation standards, but no specific requirements for energy conservation have been required for initial construction of subdivision improvements.

REGIONAL CONTEXT OF PROJECT

FIGURE 3.9



Project characteristics influencing energy use

- (a) Location of the project with respect to community services and facilities, employment centers, and mass transit lines, influencing fuel use for transportation.
- (b) The low-density, dispersed development on the site, influencing dependence on the automobile, energy requirements for construction of site improvements, and the fuel needs for heating and cooling of detached buildings.
- (c) Energy needed for construction of an artificial storm channel.
- (d) Orientation of lots, which would influence heating and cooling requirements for homes.
- (e) Lengths of streets and utility lines, and street widths, which are major determinants of initial energy input.
- (f) Provision of walking and bicycling routes as alternatives to automobile use.

These key project characteristics, as well as other minor factors influencing energy use, will be discussed in more detail in the section on mitigation measures and alternatives.

ENVIRONMENTAL SETTING RELATED TO ENERGY USE

The relatively mild climate of the San Ramon area offers the potential for energy-conserving development, provided that maximum opportunities are made to use solar energy and modify climate through lot and building orientation, use of landscaping, and other means of modifying climate.

EXISTING ENERGY SOURCES

The basic energy requirements of a residential community are for electricity and natural gas supplied by the public utility and for gasoline supplied by local retailers. The public utility (PG&E) generates its power from a number of sources, including fossil fuel and nuclear, hydroelectric and geothermal energy. P G and E allocates its energy supply according to a priority system for the entire region and could not specifically describe the sources of energy for this location. Similarly, specific sources of gasoline supplies could not be identified.

Shortages of natural gas have already resulted in temporary interruption of service for certain customers in the region, during periods of peak demand during cold winter weather. Electricity shortages, during periods of peak air-conditioning demand in summer, may become a serious problem for the region in the near future. Supplies of gasoline are dependent to some degree on foreign imports which have been interrupted in the past and which adversely affect national economic conditions.

ENERGY IMPACT OF PROJECT

Ideally, energy inputs should be calculated over the entire lifetime of the project. In the case of the Shapell subdivision, this could be one hundred years or more. However, energy inputs for urban development have varied dramatically in the past, and this variability could be expected to continue into the future. Present assumptions about energy use can be rendered obsolete by changes in technology or cultural characteristics, and it is impossible to predict the nature of these changes. Consequently, a twenty-year base period has been chosen for calculating long-term energy use for this project. Over this period, there is a reasonable likelihood that basic assumptions regarding energy use will not become obsolete, and yet the twenty-year period emphasizes the need for a look at long-term energy commitments.

It is assumed that the subdivision will be fully occupied within five years after construction of initial site improvements, with an elementary school built in the fifth year of operation. Other assumptions influencing energy impact will be noted in following sections.

In evaluating energy impact, a method has been used which combines direct and indirect energy use. Rather than attempting to identify specific quantities of fuel required, energy impact calculations have been based on research which links the total dollar cost of improvements to the total energy requirements. Thus, the

"hidden" energy inputs (such as fuel needed to manufacture sewer pipe) have been included in this evaluation.

It should be emphasized that the base data used in making this evaluation is not precise. The basic purpose of this calculation, however, is to delineate general magnitudes of energy impact for purposes of comparison with other projects and existing on-site energy use.

Initial site improvements

Site clearance and construction of streets and utilities would require direct inputs of gasoline or diesel oil for access to the site and for operation of equipment. Indirect energy input would include the energy required to produce these fuels, as well as energy for production of paving materials, utility pipe, and other construction materials.

With one exception, it is assumed that the Shapell subdivision is an "average" project in terms of its initial energy requirements, allowing the use of generalized data for conventional single-family development.¹ Since a natural drainage channel crosses the property, energy input for this construction is considered to be a separate category.

¹Figure 1.4, Category A, "Single-Family Conventional Neighborhood Development Pattern," page 11.

Streets and utilities. In conventional single-family development, total construction energy inputs are estimated at 63 therms per lineal foot of street.¹ With a total proposed street length of 18,000 feet, initial energy input for streets and conventional utilities would be:

$$63 \text{ therms/ft.} \times 18,000 \text{ ft.} = 1,134,000 \text{ therms.}$$

Artificial stream channel. In addition to conventional storm drainage construction, channelization of a natural stream course on the site is proposed. The cost of constructing an artificial channel on this site has been estimated at \$200.00 per lineal foot², or \$540,000 for the 2700' length of the channel. With an average energy input of 36,000 BTU (0.36 therm) per 1975 dollar cost of non-residential construction,³ total energy input for the artificial channel would be about 200,000 therms.

$$\begin{aligned} &\$200/\text{lineal foot} \times 2700 \text{ lineal feet} \times \\ &0.36 \text{ therm} = 194,000 \text{ therms.} \end{aligned}$$

¹Table 1.5, Category A.

²Preliminary estimate from Contra Costa County Flood Control Office, in 1975 dollars, subject to modification.

³Table 1.1, Sector 1102.

Residential construction. Construction of homes in the subdivision is expected to be spaced out over the first five years of operation. Energy input for construction, including direct input of fuel as well as indirect input for materials, is estimated at 14,500 therms per dwelling.⁴ For the 347 proposed residential units, total construction input would be about five million therms.

$$\begin{aligned} &14,500 \text{ therms/dwelling} \times 347 \text{ dwellings} = \\ &5,032,000 \text{ therms.} \end{aligned}$$

Residential operation. Heating, cooling, lighting and appliance operation is estimated at 55,000 therms per unit over a twenty-year period, including indirect energy required to produce and deliver fuel and electricity.⁵ Since some lots would be vacant during the first five years of subdivision operation, a "build-out factor" of 0.9 is used to reduce the total twenty-year input accordingly.⁶

$$\begin{aligned} &55,000 \text{ therms/unit} \times 347 \text{ units} \times 0.9 = \\ &17,176,000 \text{ therms.} \end{aligned}$$

⁴Table 1.5, Category A.

⁵Table 1.6, Category A, data for Walnut Creek area.

⁶Table 1.10, five-year projection.

Operation of utility infrastructure.

Maintenance and operation of streets and utilities would require a continuing input of energy, estimated at 1,331 therms per residential unit over a twenty-year period.¹ Total input in this category would then be:

$$1331 \text{ therms} \times 347 \text{ units} = 462,000 \text{ therms.}$$

Construction of neighborhood facilities.

A new elementary school would be required to serve the residents of the subdivision. Current costs of construction (1975) average about \$40.00 per square foot, and a typical elementary school has a floor area of about 30,000 square feet.² Total cost of the school in 1975 dollars would thus be about \$1,200,000. However, since the school would also serve the surrounding area as well as the subdivision, only part of the total input should be allocated to this particular subdivision. Assuming a school population of 550 students, and an average of 0.5 elementary students per residence,³ only about one-third of these students would come from homes in the Shapell subdivision. Dollar cost for the school,

allocated to this project, would then be about \$400,000. Based on an energy input of 0.36 therms per 1975 dollar for non-residential construction,⁴ energy input for building the school would be about 144,000 therms.

$$\$400,000 \times 0.36 \text{ therms/dollar} = 144,000 \text{ therms.}$$

Operation of neighborhood facilities. It is assumed that the school would be built in the fifth year of subdivision operation, with a floor area of 30,000 square feet. Energy input for the school is estimated at 0.87 therms per square foot per year.⁵ Over the remaining 15 years of the twenty-year base period, the operational input for the school would be 392,000 therms, with one-third of this total allocated to the Shapell subdivision.

$$0.87 \text{ therm/square foot/year} \times 30,000 \text{ square feet} \times 15 \text{ years} \times 1/3 = 131,000 \text{ therms.}$$

¹Table 1.5, Category A.

²Information from San Ramon School District.

³Table 1.3.

⁴Table 1.1, Sector 1102.

⁵Table 1.7.

Summary

The non-transportation energy inputs for this project are summarized in Table 3.10. Transportation energy use due to the subdivision was not calculated. The summary shows the importance of considering long-term inputs in evaluating energy use; only about five per cent of the total would be due to initial energy inputs, and this percentage would be even less if a longer base period would be used in making calculations.

To provide a basis for comparing this project with other proposed subdivisions, energy use per residential unit and per acre has also been noted.

TABLE 3.10

SUMMARY OF ESTIMATED ENERGY INPUTS
FOR SUBDIVISION 4820

INITIAL ENERGY INPUTS

Streets and utility construction	1,134,000 therms ¹
Other site improvements	194,000 therms
SUBTOTAL: 1,328,000 therms	

LONG-TERM ENERGY INPUTS (20-year period)

Residential construction	5,032,000 therms
Residential operation	17,176,000 therms
Utility operation and maintenance	462,000 therms
Elementary school construction (pro-rated)	144,000 therms
School operation (pro-rated)	131,000 therms
Transportation energy use ²	
SUBTOTAL: 22,945,000 therms	

TOTAL NON-TRANSPORTATION ENERGY INPUT
(20-year period)

24,273,000 therms

INITIAL INPUT PER RESIDENTIAL UNIT
PER GROSS ACRE

3,827 therms
11,160 therms

LONG-TERM INPUT PER RESIDENTIAL UNIT
PER GROSS ACRE
(20-year period)

69,951 therms
204,000 therms

¹One therm = 100,000 BTU.²Data not available.

Existing energy input and output on site

Approximately 40 acres of the site are covered by an abandoned walnut orchard, with no significant energy input for maintenance or energy output (food production). The remaining area (about 80 acres) is planted in barley.

Direct energy use (fossil fuels and electricity) for crop production of barley has been calculated at 479,000 kcal per ton.¹ Assuming an average yield of 1.3 tons per acre,² with a yearly crop production on the site of 104 tons, the yearly direct energy input on the site is now about 50 million kilocalories, or about 200 million BTU. Food value of the barley produced is estimated at 3,166,000 kcal/ton; yearly commercial energy output from the site would be:

$$3,166,000 \text{ kcal/ton} \times 104 \text{ tons} \times 4 \text{ BTU/kcal} \\ = 1.3 \text{ billion BTU's.}$$

Net yearly energy output from the site would thus be approximately 1.1 billion BTU's per year, or 22 billion BTU's over a twenty-year period. This net productivity would be reduced considerably, however, if indirect energy requirements for crop production would be taken into account.

¹Cervinka, Energy Requirements for Agriculture in California (Sacramento: California Department of Food and Agriculture, 1974), p. 113.

²Cervinka, p. 66.

Comparison of existing and proposed energy use

With the conversion of the site from agriculture to urban development, there would be a dramatic change from efficient energy production to heavy consumption of energy. Direct energy input for natural gas alone could amount to 750 billion BTU's over a twenty-year period,³ in comparison to the net output of 22 billion BTU's from agricultural use during this period.

³ Assuming average yearly direct consumption of 1200 therms per dwelling (rough estimate based on Table B-2), with a build-out factor of 0.9 (from Table 1.10).

1200 therms/home-year x 247 homes x
20 years x 0.9 x 100,000 BTU/therm.

Effect on existing energy sources

Viewed in a regional context, this project would obviously not have a dramatic effect on existing energy sources. However, as part of a continuing trend, this project will contribute to increasing shortages of natural gas and electricity. The proposed lot layout establishes a land use pattern where many homes would be poorly oriented, leading to avoidable use of energy for heating and cooling. This unnecessary energy use could aggravate peak load conditions for both summer electricity demand and winter use of natural gas for heating in cold weather. Residents living in this low-density project would be heavily dependent on the automobile for many local trips, adding to gasoline use and the need for foreign petroleum imports at a time when energy-conserving development patterns could reduce the need for automobile travel.

MITIGATION MEASURES AND ALTERNATIVES

The relation of the Shapell subdivision site to employment centers, mass transit service and various community facilities is shown in Figure 1. The location of the project with respect to these services and facilities can have an important effect on energy consumption for transportation. In addition, the site location with respect to existing utility lines should be considered.

1. "Leapfrog" development versus contiguous urbanization

In an energy-conserving community, new development takes place on land adjacent to existing built-up areas, with convenient access to community facilities. Often, however, developers seek to subdivide cheap land far beyond the existing developed areas. In addition to the extra costs to local government for providing services to "leapfrog" development, there is a waste of energy. Residents of "leapfrog" subdivisions tend to drive more, since shopping centers, schools and offices are farther away; walking and bicycling often become more difficult. Extra energy is also needed for construction of streets and utility lines to reach the project, and there is additional transmission loss in providing electricity.

The Shapell subdivision would be an addition to a current trend of expanding urbanization northward from San Ramon along Interstate 680. The project would be adjacent to existing single-family development to the south, and utility services are now available to the site. Thus, this project is an example of contiguous urbanization rather than energy-wasting "leapfrog" development.¹

¹Since no recommendation was necessary in regard to "leapfrog" development, this section could have been left out of the report. As a case study, however, the explanation was provided to demonstrate the method of evaluation.

2. Proximity of the site to community facilities and services

Energy efficiency and convenience of a subdivision is largely determined by its proximity to commercial facilities, employment, recreational facilities, supporting utilities, public facilities and services, and transportation facilities. In particular, walking and bicycling can be encouraged if facilities are located within one mile of the site.

a. Commercial facilities. The nearest commercial facilities for general shopping needs, the San Ramon-Dublin shopping center and the Danville town center, are each located within ~~several~~ miles of the Shapell site. Commercial zoning for neighborhood convenience shopping is located on Montevideo Road, about one mile from the site, and commercial zoning for additional major shopping area is located at the Crow Canyon Road interchange, approximately two miles to the north.

The Shapell site is located at the periphery of proposed residential development, and there are no prime locations on the property (such as intersections of major streets) for commercial facilities. The site is reasonably well-located with respect to existing and potential commercial development, and the energy conservation value of on-site commercial development would be marginal.

b. Employment. Most future residents of the proposed subdivision would probably follow the trend of present area residents in commuting to Oakland and San Francisco, approximately 30 miles away. The industrial park immediately north of the proposed project may serve as a minor employment destination. The availability of mass transit (see page is an existing mitigation measure for energy impact due to commuting from the site to work.

c. Schools. From an energy conservation standpoint, elementary schools should be located within one mile of residential development, so that children can walk or ride bicycles to school. Location of junior high and high schools within walking or bicycling range is also desirable.

Junior high and high school sites are located approximately 1-1/2 miles south of the site, which provides the potential for walking or bicycling for these age groups. A ten-acre elementary school site has been included in the development proposal, providing a mitigation measure for reducing automobile use for access to schools.

d. Recreation. A range of recreation facilities, including small playgrounds, neighborhood parks and playfields, should be located within walking and bicycling distance of proposed residential development. Linear park links extending throughout housing areas can

be a further incentive to walking and bicycling for recreation, in addition to providing non-motorized access to playgrounds and playfields.

A neighborhood park is located adjacent to the southwest corner of the Shapell site. However, according to the local park district, this park would not be adequate in itself to serve the need of Shapell site residents for neighborhood recommendations.

MITIGATION MEASURE: Neighborhood recreation facilities with linear park links on the Shapell site would encourage walking and bicycling for recreation and access to playfields and playgrounds.

3. Availability of mass transit

At present, the only available mass transit in the area (other than school buses) consists of BART bus feeder lines which connect the Livermore-Amador and the San Ramon Valley to the Walnut Creek BART station. The availability of this mass transit is an existing mitigation measure to reduce long-distance automobile use for commuting to work. However, the nearest stop on this bus line is several miles from the Shapell site.

MITIGATION MEASURE: An intermediate stop on the bus feeder line, closer to the proposed project, could help to encourage the use of mass transit by future project residents.

B. DEVELOPMENT CONCEPT

In addition to the location of a proposed project, the nature of the development on the site will have an important effect on energy consumption. Several alternatives and mitigation measures (discussed in the following paragraphs) are available to reduce the impact of the low-density, dispersed single-family development proposed for the Shapell site.

1. Clustering of lots for single-family units

Multiple energy savings could be obtained from grouping the dispersed residential lots on the property into compact clusters. Energy requirements for site preparation could be greatly reduced, due to the decreased length of streets and utilities per unit. Automobile travel distances within the project could be decreased by grouping units in the more accessible portions of the site. Also, the open space gained by clustering of units could provide more accessible community recreation, increase the potential for urban agriculture in community orchards and gardens, and provide corridors for pedestrian trails and bicycle paths.

The present zoning for the Shapell site requires 10,000-square-foot lots. However, 6,000-square-foot lots could provide adequate sites for future single-family homes, with the remaining 4,000 square feet of each lot combined in open space areas.

ALTERNATIVE: Clustered single-family detached housing may be developed on this site to reduce the initial energy investment, life-cycle transportation fuel consumption, and provide recreation or other amenities within walking distance without damaging the low-density single-family character of the area and without establishing a larger auto-oriented population at this distance from work, school and shopping.

2. "Zero-lot-line" regulations for attached units

In comparison with detached single-family homes, attached townhouses consume significantly less energy for space heating and cooling. To plan for attached units at the time of subdivision, "zero-lot-line" regulations would be needed to set the stage for future development of attached housing. A mix of attached and detached units may be desirable in achieving diversity in the project.

MITIGATION MEASURE: Zero-lot-line regulations may be adopted in conjunction with clustered lots to provide for energy-efficient townhouse units as part of future development of the subdivision.

3. Higher-density development

Although more residential units on a site will obviously increase the total energy impact of a project, development at higher densities may result in less energy use per unit. Apartment units are more energy-efficient than townhouses or detached single-family homes, both in terms of initial construction input and long-term energy use for heating and cooling as well as for transportation.

Development at higher densities is possible for the Shapell site, since the property is relatively flat and has the potential for intense development without excessive grading or other site preparation. Adequate utilities are also available for additional development. However, the Shapell site lies at the periphery of residential development which increases in density to the south; traffic to reach the site would pass through single-family neighborhoods. High-density development would thus be more appropriate for a site located closer to shopping and other service facilities.

C. SITE PLAN: LOT LAYOUT

The layout of lots within the Shapell subdivision could affect energy demand for construction as well as long-term energy use for future homes in the subdivision. Various suggested measures for altering lot layout to reduce energy impact are listed below. In addition, two redesigns of the subdivision, incorporating some of these methods of improvement, have been included on page

1. Grading and clearance

The topography of a site can affect the amount of fuel needed for grading of roads and homesites. Since the Shapell subdivision site is nearly level, only minimal energy input will be needed for grading.

Clearance of trees, brush and existing structures can also add to energy use. The northern third of the Shapell site is covered by approximately 600 walnut trees, with the remainder planted with barley. Most of the walnut trees are diseased and are slated for removal. There are no existing structures on the site.

A beneficial energy impact could result from this clearance if the trees would be used for firewood. Cutting of each tree for firewood would require an estimated 30,000 BTU's of fuel per tree, with an additional 60,000 BTU's per

tree for transportation if the point of use was ten miles away.¹ In return, each tree would provide five million BTU's of usable heat if used in a fireplace of 25% efficiency;² if 500 of the 600 trees on the site would be recycled as firewood, the total net energy yield would be about 2.5×10^9 BTU, or 25,000 therms.

MITIGATION MEASURE: A beneficial energy impact of 2.5×10^9 BTU, or 25,000 therms, could be obtained if 500 diseased trees on the site would be recycled as firewood.

2. Storm drainage

A natural drainage channel crosses the site from the northwest to the southeast corner. Proposed development of the site would include construction of an artificial channel, with a potential energy input of about 200,000 therms (as calculated in the section on energy impact), or about 72 therms per lineal foot of channel.

Construction of a modified natural channel in place of the artificial channel could reduce energy input per lineal foot by 50% or more.

¹Each tree is estimated to contain one cord of wood.

²A theoretical heating value of 20 million BTU's per cord is assumed, based on U.S. Forest Service data.

In Redesign A, 1,000 feet of natural channel could be used, with a potential energy savings of 36,000 therms. This savings would be doubled in Redesign B, where a modified natural channel could be used for most of the total length. This natural channel, if enhanced by landscaping, could provide aesthetic and recreational benefits as well as energy savings.

Under some conditions, on-site percolation basins could also reduce energy input for storm drainage improvements by minimizing storm runoff. However, the soil conditions on this site are unsuitable for use of percolation basins.

MITIGATION MEASURE: In place of the proposed underground conduit for storm drainage, a modified natural channel could be used (as shown in Redesigns A and B) to reduce initial energy input.

3. Adaptation to microclimate

There are no significant variations in wind conditions or solar insolation on the site which could affect lot layout. However, possible measures to avoid undesirable microclimate modification, when the site is developed, are discussed later in this report.

4. Planning for energy-conserving building orientation

The orientation of lots can have a significant effect on long-term energy use for heating and cooling homes built in a subdivision. Studies in Davis, California, have shown the energy benefits of lots laid out so that future homes can have maximum south window exposure.² Ideally, the long axis of the lot, extending away from the street, should be oriented in a north-south direction; thus, the front or rear sides of houses, with most of the windows, would face south.

In evaluating the proposed Shapell subdivision, lot orientation was seen as a critical issue, where significant energy savings could be achieved without sacrificing amenity or adding to cost. In both Redesigns A and B, re-orientation of lots was a prime consideration.

¹Data from Table 1.1, Guidelines for Evaluating Energy Impact of New Development in Contra Costa County, California. The simplified assumption is made that this energy input per dollar cost applies to the entire expense of grading and placement of the conduit as well as material cost.

²Hammond, et al., A Strategy for Energy Conservation.

MITIGATION MEASURE: To plan for energy-conserving orientation of future homes in the Shapell subdivision, a maximum number of lots could be oriented so that the long axis of the parcel (extending away from the street) would be within 30° of a north-south line.

5. Lot layout in relation to utilities

Electrical energy would be required for pumping of sewage, since a natural divide separates the Shapell site from the treatment plant in the Concord area. This pumping requirement cannot be reduced by redesign of the lot layout.

D. SITE PLAN: INTERNAL CIRCULATION

The layout of streets, utilities, sidewalks and bicycle routes within a subdivision can have an important effect on energy use. An energy-conserving circulation system can reduce initial energy for construction, in addition to diminishing long-term vehicular fuel consumption.

1. Street and utility line lengths

Initial energy inputs for grading, paving of streets and placement of utility lines are directly related to street length; shorter streets mean less energy input.

The proposed Shapell subdivision has a total of 18,000 lineal feet of streets. Since every lineal foot of street requires an average of 6.3 million BTU's of energy input,¹ a reduction in street length could provide substantial energy savings. Most of the streets in the Shapell subdivision allow through-traffic, with only 2,700 feet of cul-de-sacs. In comparison, Redesigns A and B include over 7,000 feet of cul-de-sacs. Consequently, the total street length has been reduced in these redesigns, as summarized on page 165. In addition to conserving energy, the redesigns could save the developer more than \$100,000 at current construction costs.

¹Table 1.5, page 12.

MITIGATION MEASURE: To reduce initial energy input, and reduce development costs, the total street length in the Shapell subdivision could be reduced by redesigning the project to include more cul-de-sacs.

2. Favorable traffic flow

For the most part, the street patterns in the proposed Shapell subdivision would provide direct traffic flow in and out of the project. However, there is no clear distinction between local and collector streets, and the circulation pattern is somewhat confusing. In contrast, Redesigns A and B have a clear pattern of cul-de-sacs feeding into local collector streets. In spite of the reduction of through streets in the redesigns, traffic flows still would follow reasonably direct routes in and out of the subdivision, so that no substantial increase in long-term fuel consumption should result from the redesigned street layouts.

3. Street widths

Proposed street surface widths in the Shapell project range from 32 feet to 40 feet. The County subdivision ordinance requires a width of 32 feet for minor streets, 36 feet for collectors, and 40 feet for two-lane arterials.

To reduce energy input for paving, widths of cul-de-sacs could be decreased to 26 feet. This width would still provide for two lanes of traffic, with parking on one side of the street. Even with parking on both sides of the street, adequate access for emergency vehicles could be maintained, and cars would very rarely need to meet on these lightly-traveled streets. Also, since collectors in the Shapell subdivision will need to serve only the lots within the project (no traffic would pass through the subdivision), the proposed collector widths of 36 feet and 40 feet could be reduced to 32 feet.

The energy and dollar savings from width reductions for cul-de-sacs are summarized in Table 3.11.

MITIGATION MEASURE: To reduce energy input for paving, as well as to reduce storm runoff and summer heat build-up on paved surfaces, cul-de-sac widths in the Shapell project could be decreased from 32 to 26 feet. Also, collector street widths could be reduced to 32 feet.

4. Non-motorized circulation

Sidewalks are proposed in the Shapell subdivision, in keeping with County subdivision standards. No specific bicycle routes or paths have been indicated, although the lightly-traveled streets would be available for this purpose.

To increase the attractiveness of walking and bicycling in the Shapell project, pedestrian trails and bike paths could be planned in conjunction with a linear park layout. Subdivision Redesign B indicates a layout where these energy-conserving methods of circulation could be encouraged.

MITIGATION MEASURE: Bicycle paths and pedestrian paths could be incorporated within the subdivision, increasing the attractiveness of these alternatives to the automobile.

TABLE 3.11

DOLLAR AND ENERGY SAVINGS DUE TO REDUCTION OF STREET WIDTHS¹

	<u>Linear feet of cul-de-sacs</u>	<u>Sq. ft. at 32' width</u>	<u>Sq. ft. at 26' width</u>	<u>Difference of sq. ft. bet. widths</u>	<u>Dollar Savings at \$1.00 per sq. ft.²</u>	<u>Energy Savings at 2.36 therms/dollar³</u>
Shapell Plan	2700	86,400	70,200	16,200	\$16,200.	38,232 therms
Redesigns A and B	7380	236,160	191,880	44,280	\$44,280.	104,500

¹The assumption was made that width of lightly-traveled cul-de-sac streets could be reduced from 32 feet to 26 feet without creating safety hazards or sacrificing amenity.

²Rough estimate of developer's cost for paving (1975 dollars).

³From Table 1.1, Sector 3102.

SUMMARY: SUBDIVISION REDESIGN ALTERNATIVES

Based on the preceding mitigation measures for conserving energy in the Shapell subdivision, two possible redesigns of the project were made. Redesign A contains the same number of lots as the original proposal, while the number of lots was slightly reduced in Redesign B to provide linear park space.

The basic guidelines for Redesign A included the following energy-conserving measures:

1. Re-orienting streets in an east-west direction whenever possible, thus increasing the number of lots with favorable north-south orientation.
2. Reduction of street length by emphasizing cul-de-sacs rather than through-streets.
3. Relocating open space so that a modified natural drainage channel could be used.

In addition to these guidelines, a linear park system with pedestrian and bicycle paths was included in Redesign B to increase the attractiveness of walking and bicycling rather than use of automobiles. Energy conservation benefits and cost savings of these redesigns are summarized in Table 3.12.

TABLE 3.12

COMPARISON OF PROPOSED SHAPELL SUBDIVISION WITH REDESIGNS A AND B

<u>STREET LENGTH</u>	<u>Shapell Design</u>	<u>Redesign A</u>	<u>Redesign B</u>
Total street length	18,000 ft.	16,400 ft.	16,400 ft.
Total energy input for streets and utilities (1 therm = 100,000 BTU)	1,134,000 therms	1,033,000 therms	1,033,000 therms
Energy savings (redesigns)		101,000 therms	101,000 therms
<u>LOT LAYOUT</u>			
Total number of lots	347 lots	347 lots	330 lots
Number of lots with favorable north-south orientation	226 lots	284 lots	264 lots
<u>STORM DRAINAGE</u>			
Length of energy-intensive artificial channel	2,700 ft.	1,700 ft.	700 ft.
Energy savings (redesigns) ¹		36,000 therms	72,000 therms
<u>OPEN SPACE</u>			
Total area, including school site	10 acres	11 acres	14 acres
Number of lots within 1/4-mile of open space	155 lots	325 lots	330 lots

¹Assuming use of modified natural channel reduces energy input per lineal foot by 50%.

FIGURE 3.13

SUBDIVISION 4820, SAN RAMON, CONTRA COSTA COUNTY

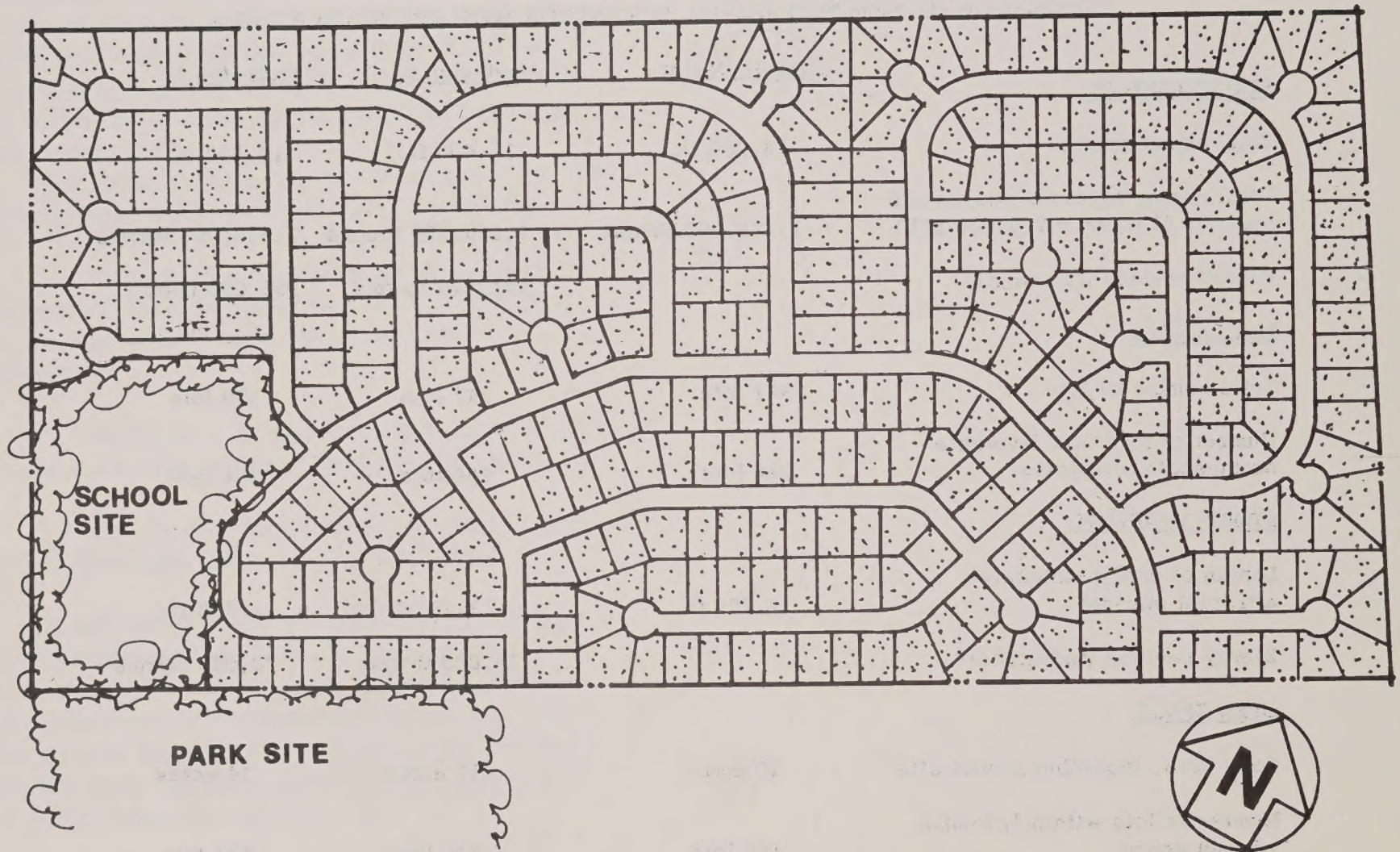
**ORIGINAL PROPOSAL**

FIGURE 3.14

SUBDIVISION 4820, SAN RAMON, CONTRA COSTA COUNTY

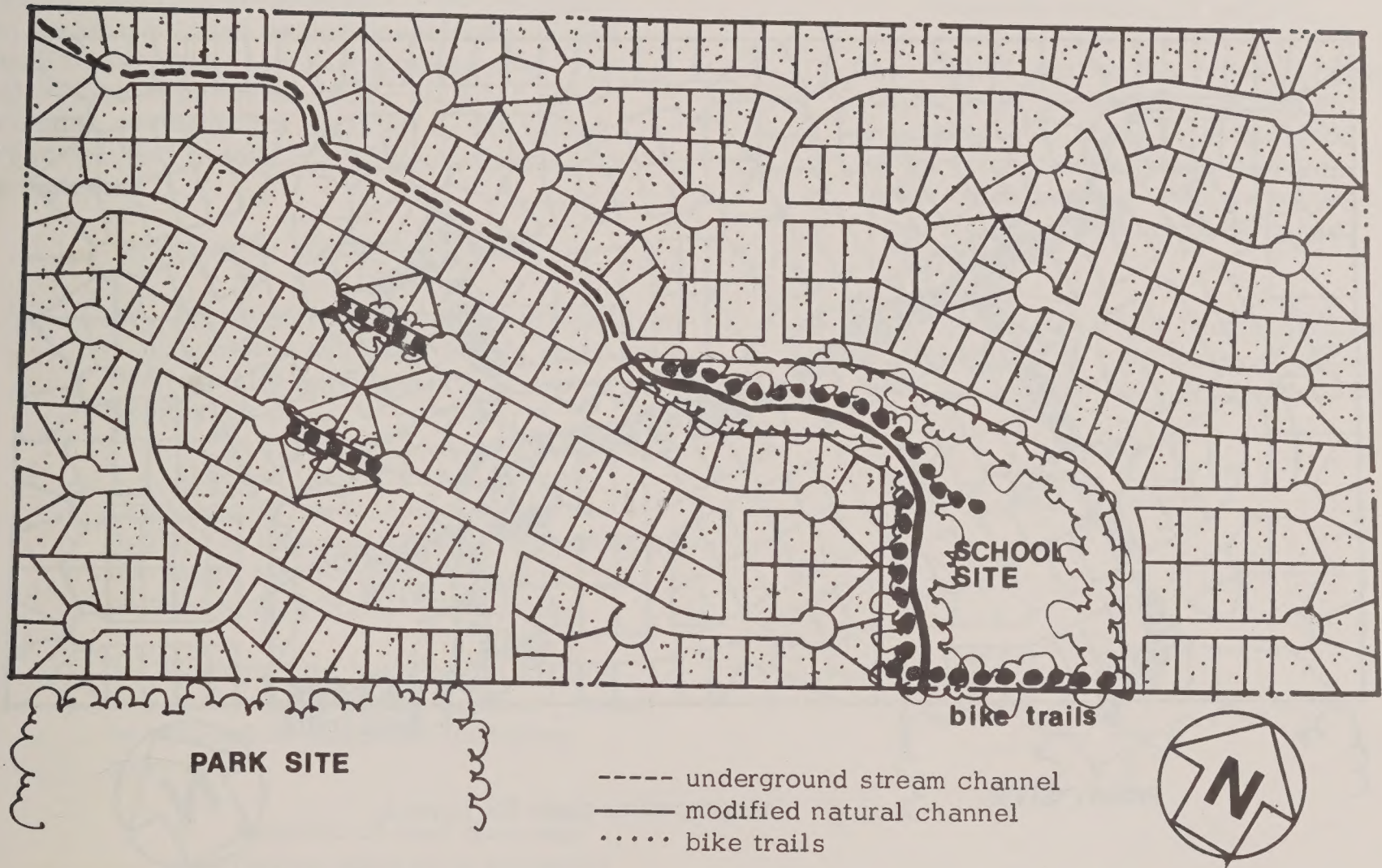
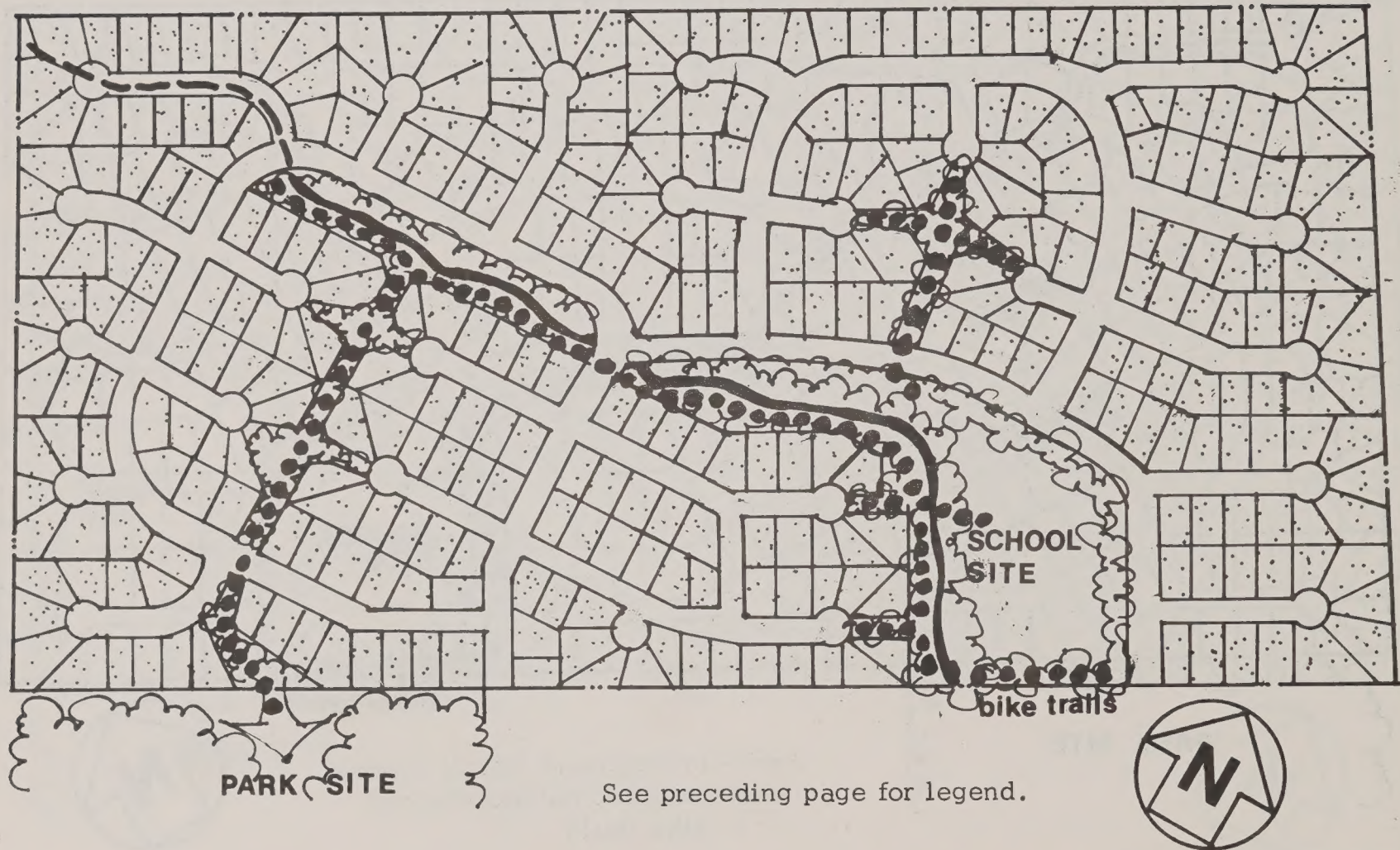
**REDESIGN 'A'**

FIGURE 3.15

SUBDIVISION 4820, SAN RAMON, CONTRA COSTA COUNTY

**REDESIGN 'B'**

E. DETAILED DESIGN CONSIDERATIONS

At the time of preliminary subdivision review, information generally is not available on various detailed design considerations and regulations which can affect energy use. The following mitigation measures are listed as possible conditions of approval by the County, when detailed of subdivision design have been established.

MITIGATION MEASURES:

1. Energy-efficient building materials, such as wood and local stone, could be used for site improvements where appropriate.
2. Reduced County street lighting requirements, now in use, could be applied to this project, and high-intensity-discharge lamps could be used to provide greater lighting efficiency.
3. Summer heat build-up on the site, due to increased paved surfaces, could be reduced by using the following measures:
 - a. Adoption of land coverage restrictions regulating unshaded paved surfaces on homesites.
 - b. Requirements for deciduous street trees at intervals of 30', with trees selected to provide maximum shading at maturity.
4. Guidelines for energy-conserving landscaping and building design on individual lots could be established at the time of subdivision approval; these guidelines, as well as suitable plant materials, could be furnished to buyers.
5. Drought-resistant landscape plants, adapted to local conditions, could be selected for planting in open space areas.

F. USE OF DECENTRALIZED OR RENEWABLE ENERGY SOURCES

Alternative energy sources are usually not considered at the stage of subdivision approval. However, it is important to establish incentives for alternative energy sources early in the development process, while avoiding regulations which could inhibit their use.

1. Solar energy

In recent years, there has been an increasing recognition of the need to protect a landowner's right to sunlight on his property. Large trees or structures on adjoining property could cast shade on a homesite, eliminating the possible use of solar energy on that parcel.

Zoning regulations for the Shapell property prohibit structures more than 35 feet in height. Side yard setbacks at 10' with 15' rear yard setbacks. Under most conditions, these regulations should be adequate to avoid undesirable shading of neighboring property by structures. However, additional regulations may be needed to assure that large trees would not block each homeowner's access to sunlight.

MITIGATION MEASURE: In addition to existing zoning regulations on the property, additional controls on trees could be adopted to assure each landowner would have the potential for using solar energy.

2. Wind power

Due to light wind conditions, use of wind generators for power is not a consideration on this site.

3. Methane

Present plans call for all homesites to be connected to sewer lines. Use of septic tanks is precluded by the small lot sizes and heavy soil conditions. However, specialized on-site systems using methane generated from domestic waste could conceivably be used as a supplementary fuel source, if health regulations would be sufficiently flexible.

MITIGATION MEASURE: Individual on-site systems for generating methane from domestic waste could be used, if health regulations would be sufficiently flexible.

4. Wood

As noted previously, firewood obtained from necessary clearance of diseased trees on the site could provide 25,000 therms of usable heating fuel.

5. Gardening and urban agriculture

Adequate space for energy-conserving vegetable gardening would be available on each parcel of the proposed Shapell subdivision. However, raising of animals for food is prohibited by the zoning of the property (Article 84-8-402). Since the keeping of pets is permitted, this regulation could be modified to allow restricted raising of animals for food.

MITIGATION MEASURE: Regulations controlling development of this property could be modified to allow the raising of certain animals for food, under conditions where noise or odor problems would not result.

G. NO PROJECT

Although there is some existing energy consumption on the site for farming, this existing energy use is balanced by usable energy output of food crops. If the site would remain in agricultural use, all adverse impacts of the proposed project obviously would be eliminated. However, the question of development pressure must be kept in mind. If this site is not converted to residential land use, the demand for housing might result in the development of a more remote site, with greater energy impacts due to increased travel distances.

UNAVOIDABLE ADVERSE IMPACTS

Construction of streets and utilities would require an unavoidable commitment of energy resources, as described on page 148, although these impacts could be reduced to some extent through application of various mitigation measures.

IRREVERSIBLE COMMITMENT OF ENERGY RESOURCES

The use of non-renewable energy sources for initial subdivision improvements would be an irreversible commitment of resources. However, many of the long-term energy impacts would not necessarily be irreversible since the potential exists for switching from fossil fuels to renewable energy sources. For example, solar energy could be used for home heating.

SHORT-TERM GAINS VERSUS LONG-TERM BENEFITS

The initial construction of bicycle paths, proposed as a mitigation measure, would add to the short-term energy impact of the project. However, long-term incentives for saving energy by using bicycles for transportation should outweigh this initial disadvantage.

The long-term benefits of present energy-efficient farming on the southern section of the site would be eliminated by the project.

GROWTH INDUCEMENT AS RELATED TO ENERGY USE

The summary of long-term energy impacts on page 151 provides a vivid picture of the large-scale commitment to growth and energy consumption on the site.

SUMMARY

1. The proposed subdivision would contribute to a long-term trend of energy-wasting, low-density residential development in the San Ramon area. Clustering of housing on the site could reduce initial and long-term energy requirements.
2. Provision of linear parks on the site could significantly reduce residents' use of the automobile.
3. By redesigning the present inefficient layout of the project, initial energy savings of 66,000 BTU could be realized, also resulting in potential cost savings of more than \$100,000 for the developer.
4. Reorientation of lots could provide significant long-term energy savings at no cost to the developer or the public, by increasing the potential for solar energy utilization and reducing wasteful east-west window orientation.

4 Evaluation of Energy Impact: Proposed Building Projects

As noted in the introduction, the primary focus of this study is on energy evaluation at preliminary phases of the development process, rather than detailed analysis of proposed construction projects. A number of existing manuals are available to provide guidance in the complicated task of analyzing the projected energy use of buildings. However, inadequate information is available on analyzing "outdoor" construction projects, such as parks and radio transmission towers.¹ Consequently, this chapter has two basic purposes:

- a. To identify existing guidelines and sources of information for evaluating proposed buildings; and
- b. To develop a general method for evaluating other construction projects.

It should be noted that energy evaluation of proposed construction projects, as a part of environmental impact report preparation, usually takes place at a preliminary design stage, when many design details affecting energy use have not been determined. Throughout this chapter, the emphasis is on those energy characteristics which can be identified and evaluated at this preliminary stage of design.

¹The energy implications of road construction are discussed in detail in Chapter 3.

Existing guidelines for evaluating proposed buildings

Perhaps the most helpful booklet for making a generalized energy evaluation of a proposed building is Energy Conservation in Building Design, prepared by the American Institute of Architects.² This 156-page booklet explains general concepts and specific measures for energy conservation, ranging from general site characteristics to specific design details. Another useful guide is a government document entitled "Energy Conservation Design Guidelines for Office Buildings,"³ containing some information which applies to other types of buildings as well. This study, prepared by the General Services Administration, includes a checklist of energy conservation measures rated according to their effectiveness under various climate conditions. Finally, Volume 3 of the Contra Costa County Energy Conservation Study contains recommendations for selected existing buildings in the county, with considerable information applied at the local level, which can also be applied to evaluation of proposed buildings.

²Available from the American Institute of Architects, 1735 New York Avenue, N.W., Washington, DC 20036 (approx. \$5.00).

³Available from the General Services Administration, 18th and F Streets, N.W., Washington, DC (approx. \$2.00).

Interrelationship of energy conservation measures for buildings

In evaluating the potential for energy conservation, the entire building must be considered as a whole—a system in which there is interaction among the exterior environment, the building envelope and structure, the mechanical and electrical systems, and the users of the building. It is important to avoid a linear, step-by-step procedure where energy conservation measures are independently evaluated one by one, since many possible energy conservation measures may conflict with each other. For example, to reduce heating requirements in the winter, window areas should be kept to a minimum, but at the same time, large window areas can reduce electrical use for lighting. In making a detailed energy evaluation of a proposed building, a set of guidelines cannot replace the technical skill of professionals who can evaluate the most beneficial energy savings and balance these measures against costs, human values, and environmental needs.

Phase 1 : Inventory

Because of the broad scope of projects covered in this chapter, no attempt has been made to prepare a comprehensive inventory of possible project and site features which can affect energy use. The inventory checklist in Chapter 2 can provide a basis for evaluation. For parks and other "outdoor" projects, an estimate of area covered by various surface treatments (paving, lawn, irrigated ground cover, drought-resistant ground cover) can be helpful in analyzing energy inputs. Total dollar cost of the project can also be important in making an estimate of total energy impact.

Phase 2: Evaluation of Proposed Energy Use

To determine initial energy input for construction, a rough estimate can be obtained if the dollar cost of the project is known. If this cost is converted to 1975 dollars, the total energy input figures per dollar in Table 1.1 can be applied to obtain the direct and indirect input for construction. For example, construction of a natural gas pipeline is proposed at an estimated 1975 cost of \$200,000. From Table 1.1, new construction of public utility facilities (Sector 1103) required an average of 36,000 BTU's per 1975 dollar. Total energy input for project construction then would be about 7 billion BTU's, or 72,000 therms.

For long-term energy requirements of residential construction, the calculation method outlined in Chapter 3 may be used. Operational energy requirements for certain types of non-residential construction may be based on Table 1.7. Total energy requirements for establishing and maintaining landscaping can be estimated from Table A-20, page 203.

Phase 3: Identification of Problems, Mitigation Measures, and Alternatives

As previously noted, there is a particular problem in recommending mitigation measures and alternatives to reduce energy consumption, since these measures may conflict. However, certain basic suggestions can be made which should usually result in energy savings within Contra Costa County. (Because of variations of climate, these measures may be ineffective or even counter-productive in other regions. The GSA energy conservation checklist, described on page 174, can be consulted to see if individual measures might be applicable in other climate zones.) These basic suggestions are summarized in Table 4.1.

Phase 4 :

Presentation of Information

The method of presentation outlined in Chapter 2, Phase 4, can also be used as a guide for preparing an energy evaluation of a specific project. In all cases, however, the current edition of the State of California Environmental Impact Report Guidelines should be consulted as the final authority on preparation of the energy component of an E.I.R.

TABLE 4.1

GENERALIZED ENERGY EVALUATION CHECKLIST:
PROPOSED BUILDINGS OR OTHER CONSTRUCTION PROJECTS

ENERGY CONSERVATION PROBLEM	POSSIBLE MITIGATION MEASURE (M) OR ALTERNATIVE (A)	A	M	CROSS- REFERENCE
A. <u>SITE LOCATION IN REGIONAL CONTEXT</u> A project site remote from existing services and facilities may result in: (a) excessive fuel consumption for access to site; (b) fuel consumption for utility line construction; (c) transmission line loss for utilities.	A-1. Choose alternate site with convenient access to services and facilities. A-2. Self-contained development: provide necessary services and facilities on site. A-3. Provide mass transit.	A	M	H-1. F-1,2,3,4,5..
B. <u>DEVELOPMENT CONCEPT</u> If project is dispersed over a large area, the development may not be energy-efficient due to dependence on the automobile, inefficient layout of streets and utilities, and use of inefficient detached buildings.	B-1. Use a "planned development" approach. B-2. Clustering of residential or nonresidential development. B-3. Use attached units. B-4. Higher-density development.	A A M A		B-2,3,4; H-1. B-1; C-1,2,3,4,5. B-1; D-1,2. B-1.

ENERGY CONSERVATION PROBLEM	POSSIBLE MITIGATION MEASURE (M) OR ALTERNATIVE (A)	A	M	CROSS- REFERENCE
C. SITE PLAN; PROJECT LAYOUT				
1. GRADING AND CLEARANCE Avoidable operation of equipment for grading, demolition or clearance in areas of steep slopes, dense vegetation or existing structures.	C-1a. Avoid intensive construction in areas of steep slopes or dense vegetation.	A		A-1; B-2.
	C-1b. Use cleared trees for firewood.		M	F-4.
	C-1c. Revise development plan to make use of existing structures.		M	
2. STORM DRAINAGE Avoidable operation of equipment and use of energy-intensive materials for stream channelization and other storm drainage improvements.	C-2a. Retain natural drainage channels on site.			B-1.
	C-2b. Reduce runoff through the use of on-site percolation basins.		M	
	C-2c. Use permeable paved surfaces.		M	
3. ADAPTATION TO EXISTING MICROCLIMATE Inefficient home heating/cooling due to development located in unfavorable microclimatic areas.	C-3. Relocate development in more favorable microclimatic areas on property: (a) south-facing slopes; (b) areas protected from winter winds; (c) locations with access to summer breezes.		M	A-1; B-2; E-3; F-1; H-1.
4. BUILDING ORIENTATION Inefficient home heating/cooling due to unfavorable window orientation.	C-4. Re-orient buildings for maximum south window exposure.		M	B-1; G-1.
5. RELATION TO UTILITIES Supplementary electricity for pumping of water and sewage may be required for project.	C-5. Relocate project at higher or lower elevation to avoid special pumping for water and sewage.		M	A-1; B-1; H-1.

ENERGY CONSERVATION PROBLEM	POSSIBLE MITIGATION MEASURE (M) OR ALTERNATIVE (A)	A	M	CROSS- REFERENCE
<u>D. SITE PLAN: INTERNAL CIRCULATION</u> 1. LENGTH OF ACCESS ROUTES AND UTILITY LINES Avoidable energy use for construction of streets and utilities, due to inefficient project layout.	D-1. Relocate project on site to reduce length of access routes and utility lines.		M	A-1; B-1; D-2.
2. TRAFFIC FLOW Inefficient automobile use due to unfavorable traffic flow.	D-2. Redesign site plan layout to provide more favorable traffic flow.		M	B-1; D-1.
3. PAVED SURFACE AREA Avoidable construction energy input, and possible impact from summer heat build-up, due to paved areas in excess of traffic and parking needs.	D-3. Reduce parking requirements and width of access routes.		M	E-3.
4. NON-MOTORIZED CIRCULATION Dependence on motorized transit due to lack of alternatives.	D-4. Provide bicycle routes and sidewalks on site.		M	

ENERGY CONSERVATION PROBLEM	POSSIBLE MITIGATION MEASURE (M) OR ALTERNATIVE (A)	A	M	CROSS- REFERENCE
E. <u>CONSTRUCTION AND MAINTENANCE OF EXTERIOR SITE IMPROVEMENTS</u>				
1. SELECTION OF MATERIALS Avoidable use of energy-intensive construction materials.	E-1. Use energy-efficient building materials.		M	
2. OUTDOOR LIGHTING Construction energy input and electricity for operation of outdoor lighting.	E-2. Reduce outdoor lighting where consistent with public safety, and use high-efficiency lamps.		M	
3. MICROCLIMATE MODIFICATION: Increased demand for electricity at peak load conditions for air conditioning, due to summer heat build-up from unshaded paved surfaces (hot-summer areas only); increased use of heating fuel due to strong winter winds.	E-3a. Provide shading for paved surfaces.		M	D-1, D-3.
	E-3b. Plant street trees.		M	
	E-3c. Use water areas for climate moderation.		M	
	E-3d. Provide windbreaks or windscreens.		M	C-3.
	E-3e. Plant deciduous trees along south walls of buildings.		M	
4. LANDSCAPE MAINTENANCE Avoidable equipment operation for lawn-mowing and other intensive maintenance of common areas; energy input for irrigation.	E-4. Keep lawn areas to a minimum and select low-maintenance, climate-adapted plantings.		M	

ENERGY CONSERVATION PROBLEM	POSSIBLE MITIGATION MEASURE (M) OR ALTERNATIVE (A)	A	M	CROSS- REFERENCE
F. <u>USE OF DECENTRALIZED OR RENEWABLE ENERGY SOURCES</u>				
1. SOLAR ENERGY	F-1a. Use solar energy for space heating. F-1b. Use solar energy for water heating (domestic hot water, swimming pools, industrial processes, etc.).		M M	
2. WIND POWER	F-2a. Use wind generators to provide electricity. F-2b. Use wind generators to pump water.		M M	
3. METHANE	F-3. Provide on-site waste disposal systems which can generate methane for use in the project.		M	
4. WOOD	F-4. Include managed woodlots in open space areas.		M	
5. URBAN AGRICULTURE	F-5. Provide areas for gardening or live stock raising in common open space of residential projects.		M	B-1, B-3.
G. <u>BUILDING OPERATION</u> Inefficient energy use for operation of heating, cooling, ventilating, lighting and other energy-consuming processes.	G-1. See references listed on page 174 for detailed treatment of energy conservation measures in building design.			
H. <u>SUMMARY</u> Serious and unavoidable adverse energy impact would result from the project.	H-1. No project.			

Appendices

APPENDIX A
SITE IMPROVEMENT ENERGY INPUTS
(Source Data and Derivations)

APPENDIX A

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TABLE A-1
STREETS AND ROADS
COSTS PER RESIDENTIAL UNIT

	A	B	C	D	E	F
	Single-Family Conventional	Single-Family Clustered	Townhouse Clustered	Walk-Up Apartment	High-Rise Apartment	Housing Mix (20% Each A-E)
<u>Capital Costs</u> ^{1,2}						
Arterial Streets	\$ 625	\$ 573	\$ 521	\$ 386	\$ 250	\$ 469
Collector Streets	364	896	703	502	321	533
Minor Streets	1,550	726	521	234	88	725
Seeding ³	17	12	7	5	3	8
Subtotal	2,556	2,207	1,752	1,207	662	1,735
Profit, Overhead, Engineering	767	662	526	362	199	520
Total	\$3,323	\$2,869	\$2,278	\$1,569	\$ 861	\$2,255
<u>Operating and Maintenance Costs</u>						
Per Year ⁴	\$ 39	\$ 29	\$ 18	\$ 11	\$ 6	\$ 20

Notes:

¹Road length calculations and standards used are presented below:

	A	B	C	D	E	F
<u>Total Road Length</u>	60.00	44.00	28.00	17.00	8.00	30.00
Arterial Streets	6.00	5.00	5.00	3.00	2.00	4.00
Percent of Total Length	10%	12%	18%	22%	27%	16%
R.O.W. Width	100'	100'	100'	100'	100'	100'
Collector Street	7.00	17.00	13.00	8.00	4.00	12.00
Percent of Total Length	12%	39%	47%	51%	54%	42%
R.O.W. Width	60'	60'	60'	70'	70'	60'
Minor Street	47.00	22.00	10.00	4.00	1.00	12.00
Percent of Total Length	78%	49%	35%	27%	19%	42%
R.O.W. Width	50'	50'	60'	60'	60'	40% 50'; 60% 60'

Source: Real Estate Research Corporation. Standards from Community Builder's Handbook (ref. no. 21-088) and Planning Design Criteria (ref. no. 21-034).

²Costs per lineal foot include curbs, gutters, sidewalks, lighting and earthwork.

STREET TYPE	R.O.W.	PAVEMENT WIDTH	LANES (Including Parking)	COST/ LINEAL FOOT	BTU x 1000/ LINEAL FOOT
Minor Street	50'	20'	2	32.98	1,683
Minor or Collector Street	60'	32'	3	52.09	2,659
Collector Street	70'	40'	4	66.87	3,413
Major Arterial	100'	64'	6	104.22	5,320

	A Single-Family Conventional	B Single-Family Clustered	C Townhouse Clustered	D Walk-Up Apartment	E High-Rise Apartment	F Housing Mix (20% Each A-E)
Arterial Streets	6.0	5.5	5.0	3.7	2.4	4.5
Collector Streets	7.0	17.2	13.5	8.7	4.8	10.24
Minor Streets	<u>47.0</u>	<u>22.0</u>	<u>10.0</u>	<u>4.5</u>	<u>1.7</u>	<u>17.04</u>
	60.0	44.7	28.5	17.0	8.9	31.78

Street Type Data from Real Estate Research Corporation, The Costs of Sprawl, April, 1974 (Table 24, p. 58).

Costs per lineal foot by Lee Saylor, Inc., Estimating Engineers, Walnut Creek, CA (1976).

BTU's per dollar of final output from Herendeen and Bullard, Energy Cost of Commerce Goods, Center for Advanced Computation, University of Illinois (Table 4B, p. 32). A 130 per cent increase between 1967 and 1973 (CALTRANS California Highway Construction Cost Index) was used to correlate 1976 costs with 1967 energy consumption per dollar of output. For new highway construction in 1967, 117,400 BTU's per dollar was required. This is approximately equal to 51,043 BTU's per dollar in 1976.

³Cost of seeding within the right of way @ \$600 per acre:

	A	B	C	D	E	F
Acres	.028	.020	.012	.008	.004	.013
Cost	\$16.80	\$12.31	\$7.48	\$4.87	\$2.62	\$8.09

Source: Lee Saylor, Inc., Estimating Engineers, Walnut Creek, CA.

⁴At \$3401 per mile per year. Includes cost of street clearing.

Source: Average of estimates from Contra Costa County Cities.

TABLE A-2
STORM DRAINAGE
DOLLAR COST PER RESIDENTIAL UNIT

	A <u>Single-Family Conventional</u>	B <u>Single-Family Clustered</u>	C <u>Townhouse Clustered</u>	D <u>Walk-Up Apartment</u>	E <u>High-Rise Apartment</u>	F <u>Housing Mix (20% Each A-E)</u>
<u>Capital Costs</u>						
Pipeline ¹	\$856.61	\$584.59	\$404.78	\$ 279.22	\$109.21	\$ 446.88
Profit, Overhead, Engineering	<u>256.98</u>	<u>175.38</u>	<u>121.43</u>	<u>83.77</u>	<u>32.76</u>	<u>134.06</u>
Total	\$ 1,113.59	\$ 759.97	\$ 526.21	\$362.99	\$ 141.97	\$ 580.94
<u>Operating and Maintenance Costs</u>						
Per Year ²	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.

Notes:

¹Includes materials, installation, earthwork, manholes and catch basins. Pipe size assumptions as follows:

<u>Pipe Size Diameter</u>	<u>Length Per Residential Unit</u>				
	A	B	C	D	E
12"	21.6	10.7	4.6	1.4	0
18"	16.2	14.3	9.1	5.4	3.2
30"	10.8	7.2	6.8	4.1	1.6
42"	5.4	3.6	2.3	2.7	0.8

Source: Real Estate Research Corporation (The Costs of Sprawl).

Costs per linear foot for reinforced concrete pipe: 12"=\$8.83; 18"=\$13.2; 30"=\$23.41; 42"=\$39.57.

Source: Lee Saylor, Inc., Cost Estimating Engineers, Walnut Creek, California.

²Reliable cost estimates for storm sewer maintenance could not be obtained. It is assumed that routine removal of debris from catch basins would be part of street maintenance costs.

TABLE A-3
SANITARY SEWERAGE
COST PER RESIDENTIAL UNIT

	A	B	C	D	E	F
	<u>Single-Family</u> <u>Conventional</u>	<u>Single-Family</u> <u>Clustered</u>	<u>Townhouse</u> <u>Clustered</u>	<u>Walk-Up</u> <u>Apartment</u>	<u>High-Rise</u> <u>Apartment</u>	<u>Housing Mix</u> <u>(20% Each A-E)</u>
<u>Capital Costs</u>						
Pipeline ¹	\$ 745.57	\$ 494.28	\$ 314.79	\$ 187.82	\$ 111.22	\$ 352.07
Manholes ²	<u>126.00</u>	<u>83.30</u>	<u>53.20</u>	<u>31.20</u>	<u>18.90</u>	<u>59.50</u>
Subtotal	871.57	577.58	367.99	219.32	130.12	411.57
Profit, Overhead, Engineering	<u>261.47</u>	<u>173.27</u>	<u>110.40</u>	<u>65.80</u>	<u>39.04</u>	<u>123.47</u>
Total	\$ 1,133.04	\$ 705.85	\$ 478.39	\$ 285.12	\$ 169.16	\$ 535.04
<u>Operating and Maintenance Costs</u>						
Pipeline ³	5.29	3.50	2.24	1.33	0.78	2.49
Treatment ⁴	20.31	20.31	19.21	19.21	16.27	19.21
Other ⁵	<u>12.07</u>	<u>24.15</u>	<u>22.84</u>	<u>22.84</u>	<u>19.34</u>	<u>22.84</u>
Total	\$ 37.67	\$ 47.96	\$ 44.29	\$ 43.38	\$ 36.39	\$ 44.54

Notes:

¹Pipes for all six neighborhoods sized in the following proportions: 70%, 8" at \$10.71 per foot; 20%, 15" at \$17.00 per foot; 10%, 30" at \$29.10 per foot. Estimates of cost include earthwork, materials, and installation. 8" and 15" pipes are vitrified clay. 30" pipes are reinforced concrete. Costs per foot derived from average of three studies. Sources: Madison-Madison, Adequacy and Cost Analysis of New Community Infrastructure; Wiedeman and Singleton, Water, Sewerage and Storm Drainage; VTN, Technical Study for New Town Development for Rancho San Diego; Lee Saylor, Inc., Estimating Engineers, Walnut Creek, CA.

SANITARY SEWERAGE
LENGTH OF PIPE PER RESIDENTIAL UNIT

	A	B	C	D	E	F
	<u>Single-Family</u> <u>Conventional</u>	<u>Single-Family</u> <u>Clustered</u>	<u>Townhouse</u> <u>Clustered</u>	<u>Walk-Up</u> <u>Apartment</u>	<u>High-Rise</u> <u>Apartment</u>	<u>Housing Mix</u> <u>(20% Each A-E)</u>
30" (10%)	5.4	3.6	2.3	1.4	0.8	2.5
15" (20%)	10.8	7.1	4.6	2.7	1.6	5.1
3" (70%)	<u>37.8</u>	<u>25.0</u>	<u>16.0</u>	<u>9.5</u>	<u>5.6</u>	<u>17.8</u>
	54.0	35.7	22.9	13.6	8.0	25.4

²One manhole every 300 feet.

Source: Seelye, Design and VTN, Technical Study for New Town Development.

Number of manholes: A - .180; B - .119; C - .076; D - .045; E - .027; F - .085. Cost per manhole is \$700.

Source: Lee Saylor, Inc., Estimating Engineers, Walnut Creek, CA.

³At \$.098 per linear foot per year.

Source: EPA, Costs to the Consumer for Collection and Treatment of Wastewater. 1973 costs escalated by 17 per cent for 1975 (CPI, Department of Commerce, Bureau of Labor Statistics).

⁴At \$5.77 per capita for activated sludge secondary treatment and two stage line clarification and filtration tertiary processes.

Source: EPA, Costs to the Consumer for Collection and Treatment of Wastewater. 1973 costs escalated by 17 per cent for 1975 (CPI, Department of Commerce, Bureau of Labor Statistics).

⁵At \$3.43 per capita for customer service and administration.

Source: EPA, Costs to the Consumer for Collection and Treatment of Wastewater. 1973 costs escalated by 18 per cent for 1975 (CPI, Department of Commerce, Bureau of Labor Statistics).

TABLE A-4
DOLLAR COST PER RESIDENTIAL UNIT FOR WATER SUPPLY

	A <u>Single-Family Conventional</u>	B <u>Single-Family Clustered</u>	C <u>Townhouse Clustered</u>	D <u>Walk-Up Apartment</u>	E <u>High-Rise Apartment</u>	F <u>Housing Mix (20% Each A-E)</u>
<u>Capital Costs (1975)</u>						
Pipeline	\$ 1,523.86	\$ 1,010.25	\$ 643.40	\$ 422.03	\$ 260.56	\$ 836.32
Hydrants	59.40	39.60	35.75	29.70	29.70	40.15
Valves	.07	.04	.03	.02	.01	.03
Subtotal	1,583.33	1,049.89	697.18	451.75	290.27	876.50
Overhead, Profit, Engineering	475.00	314.97	203.75	135.52	87.08	262.95
Total	\$ 2,058.33	\$ 1,364.86	\$ 900.93	\$ 587.27	\$ 377.35	\$ 1,139.45
<u>Operating and Maintenance</u>						
<u>Costs per Year</u>	\$ 37.23	\$ 37.23	\$ 35.22	\$ 35.22	\$ 29.88	\$ 35.22

Notes:

¹ Assumed pipe size mix (linear feet)	A	B	C	D	E	F
6" @ \$15.00 per linear foot	18.90	12.53	7.98	0	0	7.88
8" @ \$20.57 " " "	0	0	0	4.76	2.82	1.52
10" @ \$26.33 " " "	18.90	12.53	7.98	0	0	7.88
12" @ \$33.52 " " "	0	0	0	4.76	2.82	1.52
15" @ \$57.77 " " "	10.80	7.16	4.56	2.72	1.60	5.37
24" @ \$22.00 " " "	5.40	3.58	2.28	1.36	0.80	13.4

Costs include materials, installation, and earthwork. 6" to 15" pipe is cast iron; 24" is asbestos cement. Costs for F are based on the proportional housing mix and are derived from estimates for A-E.
Source: Costs from Lee Saylor, Inc.; sizes and mixes from Costs of Sprawl.

² Assumed distance between hydrants	500'	500'	350'	250'	150'	350'
Number of hydrants	.108	.072	.065	.054	.054	.073

Hydrant spacing standards based on fire protection requirements. Cost per hydrant = \$550.
Source: Costs from Lee Saylor, Inc. Spacing and number from Costs of Sprawl.

³ Assumed distance between valves						
Minor and Collector Streets	800'	800'	650'	600'	500'	650'
Arterial Streets	1,320'	1,320'	1,320'	1,320'	1,320'	1,320'
Number Valves	.069	.045	.029	.017	.008	.033
Average valve cost (based on pipe sizes)	\$.54	\$.54	\$.54	\$.84	\$.84	\$.69

⁴ At 10.55 per capita. Extrapolated from 1973 figure of \$9.04 per capita given in The Costs of Sprawl, Real Estate Research Corporation, (Table 26, page 64). Original source was derived from data on water service costs for communities in non-central city counties within SMSA's, U. S. Bureau of the Census, Local Government Finances in Selected Metropolitan Counties. Inflation factor of 17% from Consumer Price Index, United States Department of Labor, Bureau of Labor Statistics.

TABLE A-5
ELECTRICAL SERVICE
COST PER RESIDENTIAL UNIT

	A <u>Single-Family Conventional</u>	B <u>Single-Family Clustered</u>	C <u>Townhouse Clustered</u>	D <u>Walk-Up Apartment</u>	E <u>High-Rise Apartment</u>	F <u>Housing Mix (20% Each A-E)</u>
<u>Capital Costs</u>						
Underground cable ¹	\$156	\$103	\$ 66	\$ 39	\$ 23	\$ 73
Profit, Overhead, Engineering	<u>47</u>	<u>31</u>	<u>20</u>	<u>12</u>	<u>7</u>	<u>22</u>
Total	\$203	\$134	\$ 86	\$ 51	\$ 30	\$ 95

Notes:

¹ Estimated at \$2.80 per linear foot for cable type CIC including trenching, materials and installation in common trench with gas and telephone service.

Source: Pacific Gas and Electric Company.

No variation in cable size requirements by housing type is indicated.

TABLE A-6
GAS SERVICE
COST PER RESIDENTIAL UNIT

	A <u>Single-Family Conventional</u>	B <u>Single-Family Clustered</u>	C <u>Townhouse Clustered</u>	D <u>Walk-Up Apartment</u>	E <u>High-Rise Apartment</u>	F <u>Housing Mix (20% Each A-E)</u>
<u>Capital Costs</u>						
Pipeline ¹	\$135	\$ 89	\$ 57	\$ 44	\$ 26	\$ 70
Overhead, Profit, Engineering	<u>40</u>	<u>27</u>	<u>17</u>	<u>13</u>	<u>8</u>	<u>21</u>
Total	\$175	\$116	\$ 74	\$ 57	\$ 34	\$ 91

Notes:

¹ Assume two-inch pipe at \$2.50 per linear foot for neighborhoods A-C; four-inch pipe at \$3.26 per linear foot for D and E. Costs for F represent proportional housing mix. Costs include materials and installation in a common trench with electrical and telephone service.

Source: Pacific Gas and Electric Company.

TABLE A-7
TELEPHONE SERVICE
COST PER RESIDENTIAL UNIT

	A <u>Single-Family Conventional</u>	B <u>Single-Family Clustered</u>	C <u>Townhouse Clustered</u>	D <u>Walk-Up Apartment</u>	E <u>High-Rise Apartment</u>	F <u>Housing Mix (20% Each A-E)</u>
<u>Capital Costs</u> ¹						
Cable	\$300	\$242	\$200	\$100	\$ 40	\$176
<u>Operating and Maintenance Costs</u> ²						
	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.

Notes:

¹ Assumes underground cable costs.

Source: Pacific Telephone Company.

² No reliable estimates of telephone operating and maintenance costs could be obtained. N.E. = No Estimate.

TABLE A-8
STREETS AND ROADS
ENERGY INPUT PER RESIDENTIAL UNIT

	A	B	C	D	E	F
	<u>Single-Family</u> <u>Conventional</u>	<u>Single-Family</u> <u>Clustered</u>	<u>Townhouse</u> <u>Clustered</u>	<u>Walk-Up</u> <u>Apartment</u>	<u>High-Rise</u> <u>Apartment</u>	<u>Housing Mix</u> <u>(20% Each A-E)</u>
<u>BTU's x 1000</u>						
Arterial Streets	31,920	29,260	26,600	19,684	12,768	23,940
Collector Streets	18,613	45,735	35,896	29,693	16,382	27,228
Minor Streets	79,101	37,026	26,590	11,965	4,520	36,994
Seeding	<u>435</u>	<u>319</u>	<u>194</u>	<u>126</u>	<u>168</u>	<u>209</u>
Subtotal	130,069	112,340	89,280	61,468	33,738	88,371
Profit, Overhead, Engineering	<u>12,446</u>	<u>10,742</u>	<u>8,535</u>	<u>5,874</u>	<u>3,229</u>	<u>8,438</u>
Totals	142,515	123,082	97,815	67,342	36,967	96,809
Operation and Maintenance Per Year	1,990	1,480	919	561	306	1,021

Note:

See Table 1.1, Energy Cost of Selected Goods and Services.

TABLE A-9
STORM DRAINAGE
ENERGY INPUTS PER RESIDENTIAL UNIT

	A	B	C	D	E	F
	<u>Single-Family</u> <u>Conventional</u>	<u>Single-Family</u> <u>Clustered</u>	<u>Townhouse</u> <u>Clustered</u>	<u>Walk-Up</u> <u>Apartment</u>	<u>High-Rise</u> <u>Apartment</u>	<u>Housing Mix</u> <u>(20% Each A-E)</u>
<u>BTU's x 1000</u>						
Pipeline ¹	54,565	37,238	25,784	17,786	6,956	28,466
Profit, Overhead, Engineering ²	<u>4,170</u>	<u>2,846</u>	<u>1,970</u>	<u>1,359</u>	<u>532</u>	<u>2,175</u>
Totals	58,735	40,084	27,754	19,145	7,488	30,641

Notes:

¹See Table 1.1 Energy Costs of Selected Goods and Services (Concrete Products).

²See Table 1.1 Energy Costs of Selected Goods and Services (Miscellaneous Professional Services).

TABLE A-10
SANITARY SEWERAGE
ENERGY INPUTS PER RESIDENTIAL UNIT

	A <u>Single-Family Conventional</u>	B <u>Single-Family Clustered</u>	C <u>Townhouse Clustered</u>	D <u>Walk-Up Apartment</u>	E <u>High-Rise Apartment</u>	F <u>Housing Mix (20% Each A-E)</u>
<u>Construction Costs (BTU's x 1000)</u>						
Pipeline	46,435	30,785	19,606	11,698	6,927	21,928
Manholes	<u>7,847</u>	<u>5,188</u>	<u>3,313</u>	<u>1,962</u>	<u>1,177</u>	<u>3,706</u>
Subtotal	54,282	35,973	22,919	13,660	8,104	25,634
Profit, Overhead, Engineering	<u>4,243</u>	<u>2,812</u>	<u>1,791</u>	<u>1,068</u>	<u>633</u>	<u>2,003</u>
Totals	58,525	38,785	24,710	14,728	8,737	27,637
<u>Operating and Maintenance Costs</u> BTU's x 1000 (per year)						
Pipeline	329	218	139	83	49	152
Treatment	1,265	1,265	1,196	1,196	1,013	1,196
Other	<u>752</u>	<u>1,504</u>	<u>1,422</u>	<u>1,422</u>	<u>1,204</u>	<u>1,422</u>
Totals	2,346	2,987	2,757	2,701	2,266	2,770

TABLE A-11
ENERGY INPUTS PER RESIDENTIAL UNIT FOR WATER SUPPLY

	A <u>Single-Family Conventional</u>	B <u>Single-Family Clustered</u>	C <u>Townhouse Clustered</u>	D <u>Walk-Up Clustered</u>	E <u>High-Rise Clustered</u>	F <u>Housing Mix (20% Each A-E)</u>
<u>BTU's x 1000 (1975)</u>						
Pipeline ¹	94,909	62,920	40,072	26,285	16,228	52,088
Hydrants ¹	3,699	2,466	2,227	1,850	1,850	2,501
Valves ¹	<u>4</u>	<u>2</u>	<u>2</u>	<u>1</u>	<u>1</u>	<u>2</u>
Subtotal	98,612	65,388	42,301	28,136	18,079	54,591
Overhead, Profit, Engineering ²	<u>7,708</u>	<u>5,111</u>	<u>3,306</u>	<u>2,199</u>	<u>1,413</u>	<u>4,267</u>
Totals	106,320	70,499	45,607	30,335	19,492	58,858
<u>Operating and Maintenance</u> <u>Inputs Per Year¹</u> BTU's x 1000						
	2,319	2,319	2,194	2,194	1,861	2,194

Notes:

¹ 62,282 BTU/Dollar (1975), See Table 1.1 (Water, Sanitary Service)

² 16,227 BTU/Dollar (1975), See Table 1.1 (Misc. Professional Service)

TABLE A-12
ELECTRICAL SERVICE
ENERGY INPUTS PER RESIDENTIAL UNIT

	A	B	C	D	E	F
	<u>Single-Family</u>	<u>Single-Family</u>	<u>Townhouse</u>	<u>Walk-Up</u>	<u>High-Rise</u>	<u>Housing Mix</u>
	<u>Conventional</u>	<u>Clustered</u>	<u>Clustered</u>	<u>Apartment</u>	<u>Apartment</u>	<u>(20% Each A-E)</u>
<u>BTU's x 1000</u>						
Underground cable ¹	6,269	4,139	2,653	1,567	924	2,933
Profit, Overhead, Engineering ²	<u>763</u>	<u>503</u>	<u>324</u>	<u>195</u>	<u>114</u>	<u>357</u>
Totals	7,432	4,642	2,977	1,762	1,119	3,290
Operating and Maintenance Costs ³	----- not computed -----					

Notes:

¹ See Table 1.1 , Energy Cost of Selected Goods and Services. Calculated using 50 per cent electrical equipment energy cost and 50 per cent new construction public utility energy cost.

² See Table 1.1 , Energy Cost of Selected Goods and Services. Calculated using energy cost of misc. professional service.

³ Residential electrical usage in Contra Costa County ranges from an average of 3,785 KWH per year in San Pablo to 9,985 KWH per year in Moraga.

TABLE A-13
GAS SERVICE
ENERGY INPUTS PER RESIDENTIAL UNIT

	A <u>Single-Family Conventional</u>	B <u>Single-Family Clustered</u>	C <u>Townhouse Clustered</u>	D <u>Walk-Up Apartment</u>	E <u>High-Rise Apartment</u>	F <u>Housing Mix (20% Each A-E)</u>
<u>BTU's x 1000</u>						
Pipeline ¹	4,797	3,163	2,026	1,564	924	2,488
Overhead, Profit, Engineering ²	<u>649</u>	<u>438</u>	<u>276</u>	<u>211</u>	<u>130</u>	<u>340</u>
Totals	5,446	3,601	2,302	1,840	1,054	2,828
Operating and Maintenance Costs ³ .	----- not computed -----					

Notes:

¹See Table 1.1 Energy Cost of Selected Goods and Services. Calculated using Pipe Energy Cost.

²See Table 1.1 Energy Cost of Selected Goods and Services. Calculated using Misc. Professional Service Energy Cost.

³Residential gas usage in Contra Costa County ranges from an average of 926 therms per year in San Pablo, to 2,666 therms per year in Moraga. No breakdown by density types is available.

TABLE A-14
TELEPHONE SERVICE
ENERGY INPUTS PER RESIDENTIAL UNIT

	A <u>Single-Family Conventional</u>	B <u>Single-Family Clustered</u>	C <u>Townhouse Clustered</u>	D <u>Walk-Up Apartment</u>	E <u>High-Rise Apartment</u>	F <u>Housing Mix (20% Each A-E)</u>
<u>BTU's x 1000</u>						
Cable ¹	4,144	3,343	2,763	1,381	552	2,431

Notes:

¹See Table 1.1 Energy Costs of Selected Goods and Services (Communications).

TABLE A-15
 SITE DEVELOPMENT
CONSTRUCTION ENERGY INPUTS PER RESIDENTIAL UNIT

	A	B	C	D	E	F
	<u>Single-Family</u> <u>Conventional</u>	<u>Single-Family</u> <u>Clustered</u>	<u>Townhouse</u> <u>Clustered</u>	<u>Walk-Up</u> <u>Apartment</u>	<u>High-Rise</u> <u>Apartment</u>	<u>Housing Mix</u> <u>(20% Each A-E)</u>
<u>BTU's x 100,000</u>						
Streets and Roads	1,425	1,231	978	673	370	968
Storm Drainage	590	400	280	190	70	310
Sanitary Sewerage	590	390	250	150	90	280
Water Supply	1,060	700	460	300	190	590
Electrical Service	70	50	30	20	10	30
Gas Service	50	40	20	20	10	30
Telephone Service	<u>40</u>	<u>30</u>	<u>30</u>	<u>10</u>	<u>10</u>	<u>20</u>
Total	3,825	2,841	2,048	1,363	750	2,228

Notes:

¹ See page 10 for detailed descriptions of these housing categories.

TABLE A-16
SITE DEVELOPMENT
CONSTRUCTION ENERGY INPUTS PER LINEAR FOOT OF STREET

	A Single-Family Conventional	B Single-Family Clustered	C Townhouse Clustered	D Walk-Up Apartment	E High-Rise Apartment	F Housing Mix (20% Each A-E)
<u>Linear Feet of Street Per Residential Unit</u>	60	44	28	15	7	28
<u>BTU's per Linear Foot x 100,000</u>						
Streets and Roads	23.75	27.97	34.93	44.89	52.81	34.57
Sanitary Sewerage	9.75	8.81	8.82	9.82	12.48	9.87
Storm Drainage	9.79	9.11	9.91	12.76	10.70	10.94
Water Supply	16.43	14.86	15.11	18.76	25.83	19.50
Electrical Service	1.24	1.05	1.06	1.17	1.60	1.10
Gas Service	.91	.82	.82	1.23	1.50	1.01
Telephone	.69	.76	.99	.93	.79	.87
Totals	62.56	63.38	71.64	89.56	105.71	77.86

TABLE A-17
OPERATION AND MAINTENANCE OF SITE IMPROVEMENTS
ENERGY INPUT PER RESIDENTIAL UNIT PER YEAR

	A Single-Family Conventional	B Single-Family Clustered	C Townhouse Clustered	D Walk-Up Apartment	E High-Rise Apartment	F Housing Mix (20% Each A-E)
<u>BTU x 100,000</u>						
Streets and Roads	19.90	14.80	9.19	5.61	3.06	10.21
Storm Drainage ¹	-	-	-	-	-	-
Sanitary Sewerage	23.46	29.87	27.57	27.01	22.66	27.70
Water Supply	23.19	23.19	21.94	21.94	18.61	21.94
Telephone ²	-	-	-	-	-	-
Totals (Per Year)	66.55	67.85	58.70	54.56	44.33	59.85
Totals (20-Year)	1,331	1,357	1,174	1,091	886	1,197

Notes:

¹Included in Streets and Roads.

²No reliable estimate is available.

DIRECT ENERGY INPUTS
FOR STREET AND HIGHWAY CONSTRUCTION

Item	Gallons of Fuel/Unit	% Gasoline	% Diesel	Total BTU x 100,000
<u>Grading</u>				
Excavating, hauling and compacting on average major balanced project. (Use 2-3 times this amount on small projects.)				
Dirt Area	.20/cu.yd.	10	90	0.27
Rocky Area	.33/cu.yd.	10	90	0.45
<u>Hauling</u>				
Earthwork, aggregates, etc.	.02/ton mile	10	90	0.27
	.03/cu.yd.mile	10	90	0.55
<u>Crushing and Stockpiling</u>	.40/ton	5	95	
<u>Surfacing or Borrow</u>				
Loading, placing and compacting.				
	.10/ton	10	90	0.14
	.15/cu.yd.	10	90	0.20
<u>Asphalt Concrete Paving</u>				
9" slab, does not include crushing or hauling aggregates.				
	.25/sq.yd.	5	95	0.34
<u>Structural Concrete</u>	.30/cu.yd.	35	65	0.40
<u>Guard Rails</u>	.23/lin.ft.	100		0.29
<u>Median Barrier</u>	.30/lin.ft.	35	65	0.40
<u>Landscaping</u>	45/\$1,000.	100		56.78
<u>Rest Areas</u>	52/\$1,000.	50	50	68.71
<u>Illumination and Signing</u>	15/\$1,000.	100		18.93
<u>Pavement Grooving</u>	88/\$1,000.	100		111.05
<u>Fencing</u>	53/\$1,000.	100		29.02

Sources:

1. Data on fuel consumption compiled from Guidelines for Estimating Fuel Requirements for Highway Construction Projects issued by Washington State Highway Commission on 25 February 1974. Recommended for use by State of California Department of Transportation, Division of Highways, in a memorandum from W. J. Datel, State Highway Engineer, to All Division Directors dated 5 March 1974.
2. Conversion factors for gasoline and diesel fuel as follows:
 1 gallon gasoline = 126,190 BTU
 1 gallon diesel = 138,095 BTU.

TABLE A-19
BUILDING CONSTRUCTION ENERGY INPUTS PER RESIDENTIAL UNIT
(Direct and Indirect)

	A <u>Single-Family Conventional</u>	B <u>Single-Family Clustered</u>	C <u>Townhouse Clustered</u>	D <u>Walk-Up Apartment</u>	E <u>High-Rise Apartment</u>	F <u>Housing Mix (20% Each A-E)</u>
<u>Costs</u>						
Average Floor Area Per Unit (square feet)	2,100 ¹	1,600 ²	1,200 ²	1,000 ²	900 ²	1,260 ²
Cost Per Square Foot	24.63 ³	24.63 ⁴	22.17 ⁴	21.69 ⁵	38.18 ⁵	26.26
Total Cost Per Unit	52,723	39,408	26,604	21,690	34,362	33,087
BTU's x 1000 Energy Input Per Square Foot ⁶	691	691	621	607	1,069	735
BTU's x 1000 Energy Input Per Unit	1,451,100	1,105,600	745,200	607,000	962,100	926,100

Sources:

¹Contra Costa County Building Department.

²Real Estate Research Institute, The Costs of Sprawl. (Because development in unincorporated areas of Contra Costa County is predominantly single family detached, there is insufficient data available to establish averages for Types B, C, D and E.)

³Bank of America, Cost Study, Standard Quality Single Family Residence, San Francisco: Bank of America Appraisal Department, January, 1976.

⁴Cotton, Jack, Centex Homes Construction Department, Foster City, California.

⁵Real Estate Research Council of Northern California, San Francisco.

⁶Table 1.1, Energy Cost of Selected Goods and Services.

TABLE A-20

COMPARATIVE ENERGY INPUTS FOR LANDSCAPING

IN LIVERMORE, CALIFORNIA (20-year period, per 1000 sq. ft.)

<u>Item</u>	<u>BTU x 100,000</u>
Bluegrass lawn	316
Irrigated shrubbery	244
Irrigated ground cover	200
Native drought-resistant ground cover	48

Source: Dahlin, The Greedy Lawn, p. 17.

APPENDIX B

BUILDING ENERGY USE PROJECTIONS FOR FUEL AND ELECTRICITY

(Source Data and Derivations)

APPENDIX B

BUILDING ENERGY USE PROJECTIONS
FOR FUEL AND ELECTRICITY1. RESIDENTIAL ENERGY USE PROJECTIONS

There is available from P G and E current (1975) data on average residential gas and electricity use for 15 representative areas of Contra Costa County.¹ This data appears to correlate rather significantly with climatic conditions (heating and cooling degree days). Beyond that, there appears to be little usable data currently

available that would correlate building type and density type with the actual average residential use of gas and electricity. One HUD study² based on theoretical rather than empirical data, indicates that in the Washington D.C. area, the relationship of characteristic dwelling energy use in various dwelling densities is as follows:

TABLE B-1
RATIO OF ANNUAL ENERGY CONSUMPTION
FOR RESIDENTIAL TYPES
(Single Family = 1.00)

<u>Unit Type</u>	<u>Area (SF)</u>	<u>Gas heating per square foot</u>	<u>Gas heating per unit</u>	<u>Cooling (electric) per square foot</u>	<u>Cooling (electric) per unit</u>
Single Family	1695	1.00	1.00	1.00	1.00
Townhouse	1300	0.79	0.68	1.88	1.65
Low-Rise	1140	0.62	0.46	1.11	0.84
High-Rise	850	1.58	0.37	0.62	0.40

¹Pacific Gas and Electric Company, Annual Residential Use Report, Gas and Electric Consumption Per Average Annual User for the Year 1975 for Each Incorporated City (San Francisco: P G and E Reports Section, Economics and Statistics Department, Office of the Vice President—Rates and Valuation, February, 1976).

²Department of Housing and Urban Development, Office of the Assistant Secretary for Policy Development and Research, Residential Energy Conservation (Washington, D.C.: HUD Report No. HUD-HAI-8, July, 1974).

TABLE B-2

<u>1975 ELECTRIC</u> <u>AVERAGE ANNUAL USAGE</u>				<u>1975 GAS</u> <u>AVERAGE ANNUAL USAGE</u>			
	<u>No. of Customers</u>	<u>KWHR</u>	<u>% Increase</u>		<u>No. of Customers</u>	<u>Therms</u>	<u>% Increase</u>
Albany	5,522	3,594	1.8	Albany	5,449	934	11.7
Antioch	11,479	6,864	0.3	Antioch	11,181	1,019	8.3
Clayton	553	10,284	3.5	Clayton	534	1,519	5.7
Concord	31,482	6,552	2.1	Concord	29,315	1,131	7.3
El Cerrito	9,446	4,851	1.8	El Cerrito	9,233	1,105	4.6
Hercules	50	4,984	3.4	Hercules	49	985	1.8
Lafayette	7,185	8,191	1.7	Lafayette	6,700	1,703	5.0
Martinez	6,573	5,974	3.0	Martinez	6,417	1,121	5.3
Moraga	4,152	8,741	-12.5	Moraga	3,721	2,016	-24.4
Pinole	4,932	6,997	4.6	Pinole	4,574	1,346	7.9
Pittsburg	8,302	6,191	2.2	Pittsburg	8,218	1,096	9.1
Pleasant Hill	9,125	6,750	4.1	Pleasant Hill	7,472	1,232	6.8
Richmond	25,325	4,542	1.8	Richmond	25,042	949	-12.6
San Pablo	6,915	3,767	-0.5	San Pablo	6,791	930	0.4
Walnut Creek	20,150	7,028	3.7	Walnut Creek	15,650	1,262	6.6

Source: Pacific Gas and Electric Company, Annual Residential Use Report, Gas Consumption Per Average Annual User for the Year 1975 for Each Incorporated City (San Francisco: P G and E Reports Section, Economics and Statistics Department, Office of the Vice President—Rates and Valuation, February, 1976).

Another recognized reference^{1,2} on the relationship between type and density of residential unit and energy use was used as a source for neighborhood cost analysis in The Costs of Sprawl:

TABLE B-3³

RATIO OF ANNUAL ENERGY CONSUMPTION
FOR RESIDENTIAL TYPES
(Single Family = 1.00)

<u>Unit Type</u>	<u>Area (SF)</u>	<u>Gas Use per SF</u>	<u>Gas Use per Unit</u>	<u>Electrical Use per SF</u>	<u>Electrical Use per Unit</u>
Single Family Conventional	1600	1.00	1.00	1.00	1.00
Single Family Clustered	1600	1.00	1.00	1.00	1.00
Townhouse Clustered	1200	0.89	0.67	0.66	0.88
Walk-Up Apartment	1000	0.81	0.51	0.58	0.93
High-Rise Apartment	900	1.75	0.42	0.59	1.05

¹Hittman Associates, Inc., Residential Energy Consumption: Multi-Family Housing Data Acquisition (Columbia, Maryland: Hittman Associates, 1972).

²Hittman Associates, Inc., Residential Energy Consumption. Phase I Reports (Columbia, Maryland: Hittman Associates, 1972).

³Real Estate Research Corporation, The Costs of Sprawl, pp. 66-67. These ratios were derived from the Tables 30 and 31 for Neighborhood Cost Analysis, Gas and Electricity, in order to match the format in the rest of this study.

TABLE B-4¹

RATIO OF "ALL ELECTRIC" ANNUAL ENERGY CONSUMPTION
FOR RESIDENTIAL TYPES
(Single Family = 1.00)

<u>Unit Type</u>	<u>Area (SF)</u>	<u>Electric Use per SF</u>	<u>Electric Use per Unit</u>
Single Family Conventional	1600	1.00	1.00
Single Family Clustered	1600	1.00	1.00
Townhouse Clustered	1200	0.64	0.87
Walk-Up Apartment	1000	0.49	0.78
High-Rise Apartment	900	0.42	0.74

The 1970 Census Summary Tape (Housing) includes a number of matrices which might prove helpful in correlating gas and electric usage with housing types. However, it is not within the

scope of this study to attempt such a complete and time-consuming task. The 1975 census (as well as the 1970 census) provides a breakdown of housing unit types for each census tract as shown in Table B-5.

¹Real Estate Research Corporation, The Costs of Sprawl, pp. 66-67.

TABLE B-5
HOUSING TYPES BY CITIES
1975 Census

<u>CITY</u> <u>Census Tracts</u>	<u>SINGLE FAMILY</u> <u>Per Cent</u>	<u>2-4 UNITS/BLDG</u> <u>Per Cent</u>	<u>5+ UNITS/BLDG</u> <u>Per Cent</u>	<u>MOBILE HOMES</u> <u>Per Cent</u>	<u>OTHER</u> <u>Per Cent</u>	<u>TOTAL</u>
ANTIOCH 6 Tracts	8,594 73%	1,217 10.3%	1,782 15.2%	115 0.9%	0	11,708
BRENTWOOD 2 Tracts	871 64.8%	131 9.7%	186 13.8%	156 11.6%	0	1,344
CLAYTON 1 Tract	520 90.1%	15 2.6%	40 6.9%	0	2	575
CONCORD 20 Tracts	21,500 64.3%	2,393 7.1%	8,121 24.3%	1,378	0	33,392
EL CERRITO 10 Tracts	7,037 75.1%	1,336 14.2%	895 9.5%	90	0	9,358
HERCULES 1 Tract	43 81.1%	10 18.9%	0	0	0	53
LAFAYETTE 9 Tracts	5,406 77.%	547 7.7%	1,060 15.1%	4	0	7,017
MARTINEZ 8 Tracts	4,905 72.2%	1,097 16.1%	785 11.5%	2	4	6,793
MORAGA 4 Tracts	3,081 68.7%	571 12.7%	832 18.5%	0	0	4,484
PINOLE 5 Tracts	3,990 82.3%	311 6.4%	546 11.2%	1	0	4,848
PITTSBURG 8 Tracts	6,671 73.9%	1,462 16.2%	776 8.6%	101	10	9,020
PLEASANT HILL 8 Tracts	6,582 72.4%	369 4.0%	2,086 22.9%	54 0.5%	0	9,091
RICHMOND 21 Tracts	17,993 65.6%	5,768 21.0%	3,630 13.2%	8	3	27,402
SAN PABLO 4 Tracts	4,209 52.1%	1,294 16.0%	1,647 20.4%	909 11.2%	9	8,068
WALNUT CREEK 10 Tracts	8,405 41.9%	3,233 16.1%	8,394 41.8%	15 0.1%	0	20,047

Another P G and E Report¹ prepared by the Marketing Research and Services Department, gives some insight into the characteristics of those users on the lower end of the consumption scale. The results indicate that low usage is more closely related to life style and appliance ownership than to income level. The low usage customers generally fell into two categories: young working people living in apartments who are in the middle income range, and retired persons living off of fixed income pensions and social security. Appliance ownership was often limited by the landlord or physical space. Only 14 per cent of the low usage customers live in single-family residences, the rest live in multi-unit buildings or mobile homes.

Using the 1975 census data for ratios and locations of housing types (Table B-5), and the average annual usage (Table B-2), it is possible to apply as assumptions some of the use factors perviously described in Tables B-1, B-3 and B-4, and derive a breakdown of the overall observed average use as shown in the example below:

Using Antioch data:

<u>Type of Housing</u>	<u>Total No. of Units</u>	<u>Per Cent Distribution</u>
Single-Family		
Detached	8,594	73.4
Multiple-Family	<u>3,114</u>	<u>26.6</u>
Total	11,708	100.0

Let: x = Single-Family gas use in therms per unit
 y = Multiple-Family gas use in therms per unit.

From Table B-3:

$$y = .51x$$

From Tables B-2² and B-5:

$$.734x + .266y = 1,019 \text{ therms}$$

$$.734x + .266y = 1,019 \text{ therms}$$

$$.734x + .266(.51x) = 1,019 \text{ therms}$$

$$.734x + .136x = 1,019 \text{ therms}$$

$$.870x = 1,019 \text{ therms}$$

$$x = 1172 \text{ therms (average single-family unit use)}$$

$$y = .51x$$

$$y = 598 \text{ therms (average multiple unit use).}$$

This type of analytical breakdown of utility use by building type and location is summarized in Table 1.6 and is about the best that can be done using available data, but it should be emphasized that it is plagued by deficiencies that make its usefulness questionable. By using historical data, the method fails to take into account the effect on all future building of prescriptive energy legislation such as California Title 24 and Title 25 Energy Insulation Standards for Residential Buildings and the growing economic incentives for energy-saving building design techniques and energy-efficient appliances.

¹Pacific Gas and Electric Company, Residential Low Usage Customer Survey (San Francisco: P G and E Market Research and Services Department, May, 1972).

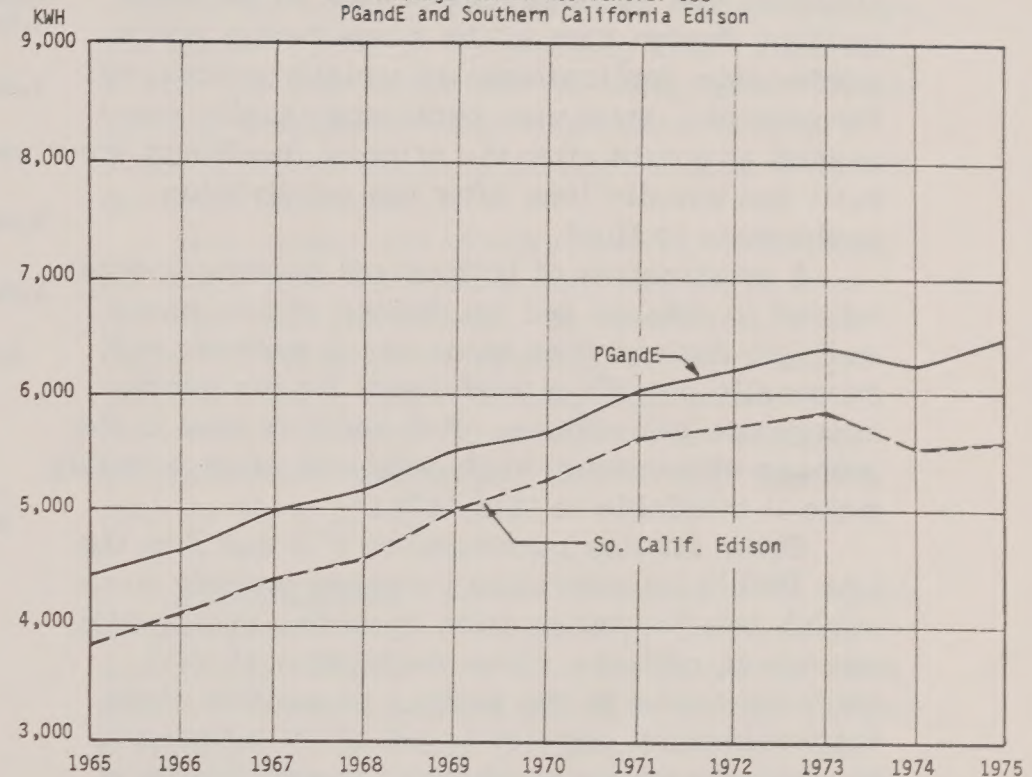
²Since no differentiation among types of multiple units was made, we are assuming that all are "walk-up" apartments. Since no data is available on the ratio of mobile home usage, they are also treated as "walk-up" apartments since they exhibit generally the same reduced use per unit patterns in relation to single-family conventional.

More importantly, there is no means by which the data can be allocated to recognize demographic differentiation in building types, ages and occupancy lifestyles. Working counter to what would seem an obvious trend toward energy conservation is the observed history of steadily increasing use per residential unit of both gas and electricity with only a temporary dip during the "energy crisis" of 1973-74 as shown in Figures B-6 and B-7 furnished by P G and E. Also, as natural gas supplies dwindle and become increasing expensive and unreliable, more electricity with a higher primary energy input will be used, thus offsetting the lower on-site energy consumption of future dwellings.

With over 7,420 pools in Contra Costa County having recorded building permits and an unknown number of above-ground pools without permits, the averages in Table B-2 obviously have a built-in factor for swimming pool heating. If an average 600 square foot residential swimming pool uses 2,000 therms of gas in a five-month-long heating season, it would have a consumption almost equal to the highest average total residential yearly consumption as in Table B-2.

FIGURE B-6

ELECTRIC DEPARTMENT

Average Annual Residential Use
PGandE and Southern California Edison

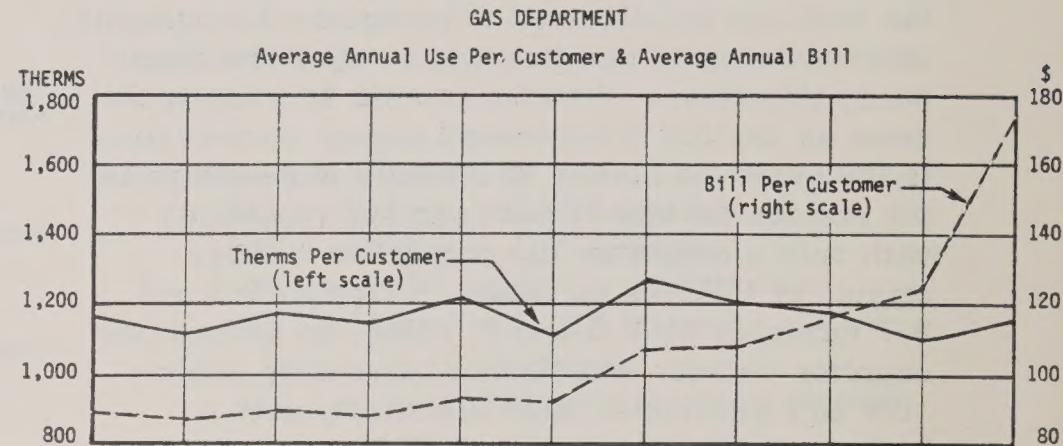
12 Months Ended	AVERAGE ANNUAL RESIDENTIAL USE					
	PGandE			So. Calif. Edison		
	Kwh	Incr.	%	Kwh	Incr.	%
December 1965	4,454	205	4.8	3,820	254	7.1
1966	4,661	207	4.6	4,094	274	7.2
1967	5,000	339	7.3	4,425	331	8.1
1968	5,181	181	3.6	4,609	184	4.2
1969	5,545	364	7.0	5,031	422	9.2
1970	5,697	152	2.7	5,240	209	4.2
1971	6,048	351	6.2	5,642	402	7.7
1972	6,213	165	2.7	5,777	135	2.4
1973	6,417	204	3.3	5,885	108	1.9
1974	6,260	(157)	(2.4)	5,541	(344)	(5.8)
1975	6,462	202	3.2	5,596	55	1.0

Accepted engineering practices for calculating the major components of energy use such as heat loss and gain are also of questionable practical use because normal lack of detailed building design data at the stage during which subdivision applications are usually processed. For example, swimming pools are usually processed at a date after the original dwellings are built and usually long after the subdivision application is filed.

A combination of both recent/historical data related to climate and conditions of occupancy, and data derived from engineering methods will eventually provide a useful tool for residential energy use projections. P G and E is now in the process of preparing such data and might possibly make it available in late 1976.¹

Other studies performed by P G and E in the late 1960's for marketing purposes provide some useful detailed information regarding residential gas usage patterns. One such project² that might be useful to the serious researcher finds that residential gas use is primarily influenced by space heating use which is predominantly a function of weather, specifically the number of degree days. The monthly variation in water heating gas use is slight compared to space heating, but exhibits a marked seasonal variation due to inlet water temperatures.

FIGURE B-7



12 Months Ended	AVERAGE ANNUAL								
	Use Per Customer			Bill Per Customer			Revenue Per Therm		
	Therms	Incr.	%	\$	Incr.	%	\$	Incr.	%
December 1965	1,175	(25)	(2.1)	88.97	(1.53)	(1.7)	7.574	0.034	0.5
1966	1,126	(49)	(4.2)	87.03	(1.94)	(2.2)	7.731	0.157	2.1
1967	1,184	58	5.2	89.97	2.94	3.4	7.599	(0.132)	(1.7)
1968	1,152	(32)	(2.7)	88.20	(1.77)	(2.0)	7.658	0.059	0.8
1969	1,216	64	5.6	93.14	4.94	5.6	7.662	0.004	0.1
1970	1,125	(91)	(7.5)	92.69	(0.45)	(0.5)	8.238	0.576	7.5
1971	1,270	145	12.9	107.93	15.24	16.4	8.495	0.257	3.1
1972	1,205	(65)	(5.1)	107.99	0.06	0.1	8.960	0.465	5.5
1973	1,185	(20)	(1.7)	117.44	9.45	8.8	9.908	0.948	10.6
1974	1,100	(85)	(7.2)	124.86	7.42	6.3	11.353	1.445	14.6
1975	1,166	66	6.0	172.37	47.51	38.1	14.787	3.434	30.2

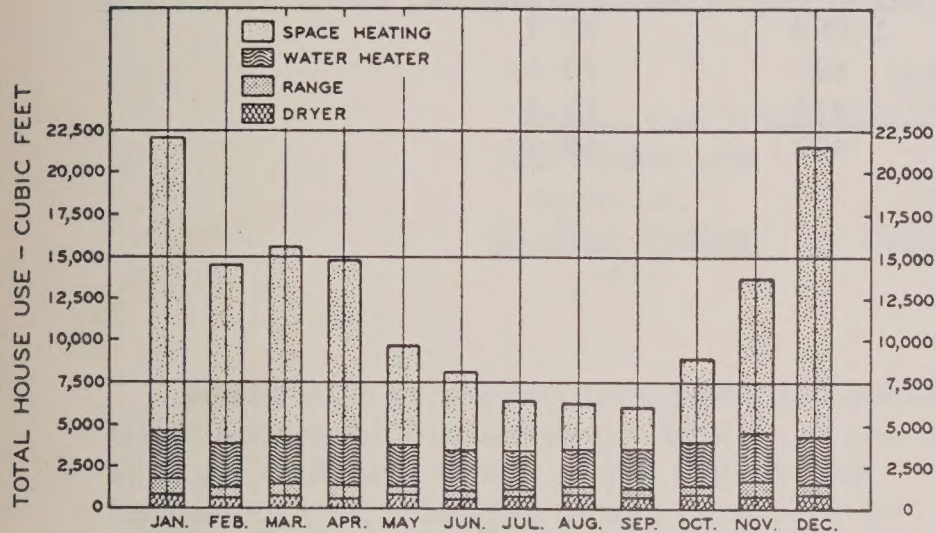
¹This information is from a phone conversation 12 March 1976 with Frank Burney of the Land Use Planning Division of P G and E (415/781-4211, extension 2641).

²Pacific Gas and Electric Company, Residential Gas Appliance Load Research Project (San Francisco: P G and E Marketing Research and Services Department, September, 1970).

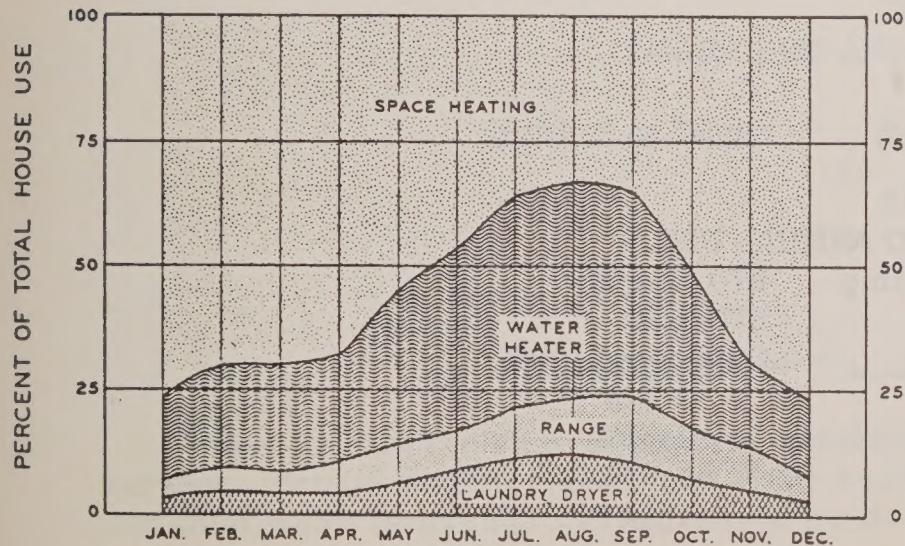
FIGURE B-8

THE ALL GAS HOME
SAN FRANCISCO BAY AREA
P. G. & E.

A. MONTHLY TOTAL HOUSE USE SEGREGATED
TO FUNCTION



B. MONTHLY PERCENT OF TOTAL HOUSE USE
BY APPLIANCE



Total gas use increases as family size increases, but the use per family member decreases as family size increases. Space heating, the largest factor in determining total house use, is not markedly dependent on family size. Water heating exhibits a definite increase as family size increases which is distinct enough to affect the total house use.

Gas ranges and laundry dryers, when used, provide a non-fluctuating gas load which does not vary with the season. In an all-gas home (space heating, water heating, cooking and clothes dryer), space heating represents 64.3 per cent of the total house use, water heating 23.4 per cent, the range 6.9 per cent, and the clothes dryer 5.4 per cent.

Space heating. In the homes studied, space heating represented 69.7 per cent of the total gas usage. Eighty-five per cent of the variation in space heating demand was due to degree days. This averaged at 0.219 therms per degree day at a 70°F. base. Shown below is Table B-9 which relates therms to degree days.

TABLE B-9

	DD 1967-68 <u>70° Base</u>	Average <u>Therm Use</u>	% Space Heating <u>to Total House</u>
Pinole	4,869	1,088	72.7
Santa Cruz	4,746	897	70.3
San Jose	<u>3,911</u>	<u>918</u>	<u>65.4</u>
Average	4,509	990	69.7

The report found that uninsulated homes used an average of 51 per cent more gas for space heating than fully-insulated homes. Since house sizes in the study varied only from 1100 to 1400 square feet there was no distinct correlation between home size and gas space heating usage. However, the connected load (the sum of the continuous ratings of the power-consuming apparatus connected to a system) also appears to be a principal determinant in total space heating gas usage. As homes recorded larger connected loads, the annual average use increases but not at as fast a rate as connected load increase, as shown in Table B-10 below.

TABLE B-10
CONNECTED LOAD AND ANNUAL USE

BTU/Hr Rating of Space Heating <u>Load</u>	Space Heating Average <u>Therm Use</u>	BTU Use Per BTU/Hr <u>Connected Load</u>
35,000	724	2,067
80,000	911	1,139
90,000	1054	1,171
100,000	1147	1,147

Water Heating. The average water heating load in the study was 360 therms with a further breakdown shown in Table B-11 below:

TABLE B-11 GAS WATER HEATING LOADS IN THERMS		
<u>Dishwasher and Automatic Clothes Washer</u>	<u>Automatic Clothes Washer</u>	<u>No Dishwasher or Automatic Clothes Washer</u>
416	336	263

Family size appears to have a very influential effect upon water heating use. Families of six used 56.2 per cent more therms of gas than did the families of two. Families of five used 13.5 per cent more therms than did families of four.

TABLE B-12 FAMILY SIZE AND WATER HEATING ENERGY		
<u>Number in Family</u>	<u>Annual Therms</u>	<u>Therms per Family Member</u>
2	285	143
3	288	96
4	374	93
5	424	85
6	445	74
Total Average:	369	

There appeared to be a 95 per cent correlation between average monthly gas use for water heating and inlet water temperature as expressed by the regression formula below:

$$\text{Therms of Gas/Month} = 59.44 - 0.45 (\text{Inlet water temperature in } ^\circ\text{F.})$$

Range. Annual average gas range usage was 107 therms representing 8.0 per cent of total house use in the study. The usage does not appear to be significantly linked to any variable except user lifestyle.

P G and E has not performed any similar studies for electric usage, but Table B-13, below, might provide some insight into electrical consumption in an "average" single family dwelling:

TABLE B-13

ANNUAL PRIMARY ENERGY CONSUMPTION
FOR A TYPICAL RESIDENTIAL STRUCTURE IN THE
BALTIMORE-WASHINGTON AREA

<u>Component</u>	<u>All electric house, therms¹</u>	<u>Minimum energy house, therms</u>
Hot Water Heating	480 ²	270 (G)
Lights	218	218 (E)
Range	120	50 (G)
Refrigerator/Freezer	200	200 (E)
Clothes Dryer	108	40 (G)
Color TV	54	54 (E)
Furnace Fan	0	43 (E)
Dishwasher	40	40 (E)
Clothes Washer	11	11 (E)
Iron	16	16 (E)
Coffee Maker	11	11 (E)
Outside Light	90	90 (E)
Miscellaneous	<u>131</u>	<u>131 (E)</u>
	1,487	1,174

(E) Electric

(G) Gas

¹One therm = 10^5 BTU = $1,055 \times 10^5$ kJ.²Electric power based on power plant energy consumption of 10,910 BTU/kW-hr.

Source: "Technology of Efficient Energy Utilization:" Report of a NATO Science Committee Conference Held at Les Arcs, France; October 8-12, 1973; p. 46.

APPENDIX C

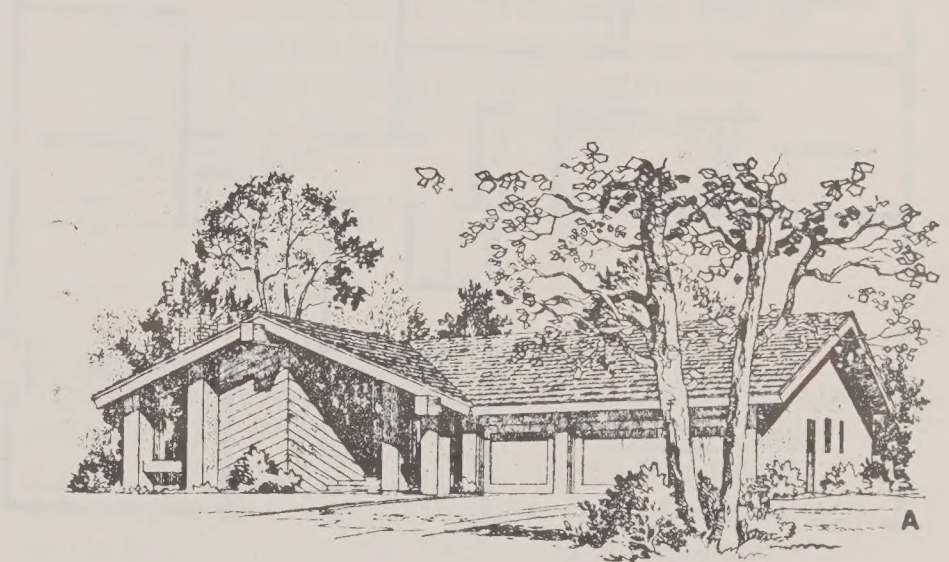
ENERGY CONSERVATION AND BUILDING ORIENTATION

Solar heat gain through glass is desirable in winter when it can reduce the overall requirement for space heating. In the summer, the same type of solar heat gain is usually undesirable as it contributes significantly to air conditioning requirements—usually during times of electrical peak loading. For good energy conservation it is generally a good rule to concentrate glass areas on the south-facing walls, and to provide shading that will preclude high summer sun and admit low winter sun. Drapes or shutters with some insulative value can reduce heat losses in winter when closed at night or during cloudy weather.

Because of zoning codes which prohibit or discourage privacy fencing on the street side of lots, and because of normally narrow side yards, most tract-type housing is usually designed with a predominance of glass area on the rear elevation where it faces a relatively large and private rear yard. For aesthetic reasons, the front elevation usually has the second largest glass area, but it is often protected by overhangs, porches, or other architectural treatments that recall a time when such devices served the functional purpose of alleviating the harsh effects of wind, sun and rain.

For economy of construction and because they are not exposed to public view, the rear and side elevations usually do not include generous overhangs or other architectural treatments which can provide protection from summer solar heat gain.

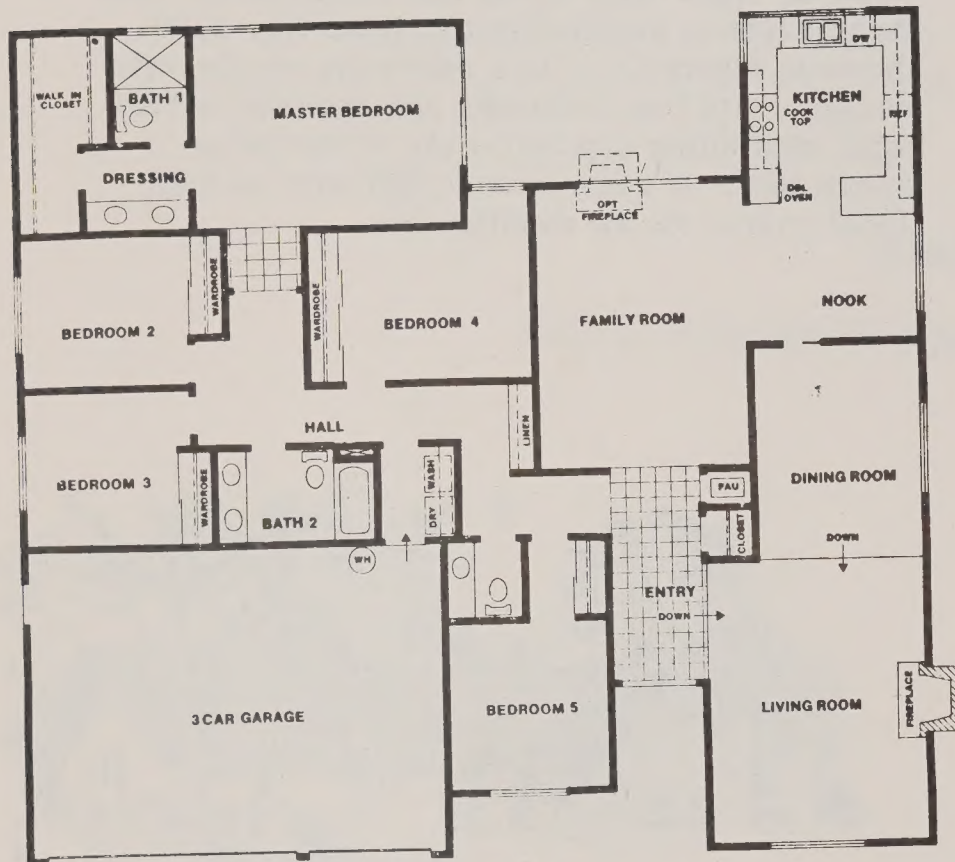
To relate some of the principles of window design and building orientation to actual building conditions in Contra Costa County, Interactive Resources, Inc., made a detailed analysis of a "typical" tract home in the San Ramon area. The Shapell Homes Rancho Ramon Model No. 2250, shown in Figure C-1, is a one-story ranch-style dwelling with four bedrooms and two-and-a-half baths containing approximately 2,940 gross square feet. It sells for \$77,800 with an additional charge for air conditioning.



Shapell Case Study Home

FIGURE C.1

SHAPELL CASE STUDY HOME FLOOR PLAN



The case study dwelling has 368 square feet of glass doors and windows distributed as follows:

<u>Elevation</u>	<u>Glass Area in Square Feet</u>
Front	97
Right Side	94
Rear	133
Left Side	44
	<u>368</u>

With the exception of the entry area, the roof overhang is a standard 18 inches on all sides.

The principal area of investigation involved simulating solar gain through glass with the house oriented four different directions during typical winter and summer sun conditions.

Because the purpose is to illustrate particularly the effect of orientation on heat gain, we have taken the liberty of eliminating the 52 square foot Master Bedroom sliding glass door and treat the house more like a rectangle. It will be shown, however, that if the same door were moved to the rear wall it would have the potential of increasing needed winter heat gain and decreasing summer heat gain.

Tables C-2 and C-3 show graphically the mid-winter sun and shade patterns with four alternate site orientations, that is, with the rear elevation facing north, east, south and west. The solar heat gain with the rear elevation (the one with the most glass area) facing south is approximately 61 per cent higher than the next most

favorable orientation (north) and over 89 per cent more favorable than the least favorable orientation (west). With an additional sliding glass door on the rear of the master bedroom instead of the alcove side, the building would benefit by at least an additional 50,000 BTU of daily solar radiation. This solar gain is essentially fuel-free heat, and the lesson is that, in the case of this tract design home, the "free" heat can only be maximized through proper building and site orientation.

Tables C-4 and C-5 shown sun and shade patterns for the same house and alternate site orientations during the hottest part of the summer. The south orientation of the rear elevation results in 28 to 30 per cent less solar gain than if it were facing west or east. In fact, if the overhang over the sliding glass door in the family room were extended another 18 inches, the entire facade would be in shade and the total heat gain would be approximately the same as if the rear elevation were facing north.

The effect of the 25,853 BTUH occurring at 4:00 p.m. with a rear orientation west is equivalent to at least two tons of air conditioning capacity. It is evident that, with proper site and building orientation, this tract home would not only use substantially less energy for summer cooling, but it would also require less or perhaps no capital investment for air conditioning equipment.

One highly reputable study¹ of solar heat gain through windows concludes:

"For southern faces, any of the windows considered....which will have high winter solar transparency and are suitably shaded in the summer will be more effective in saving energy than the best insulated wall. Indeed, most of the systems have a net positive energy gain. For the better thermally-insulated window systems this will be true for the east and west-facing window also. This is a very important point because the intuitive feeling that the most effective building design from an energy (presumably not aesthetic) view would be a structure without windows is not true."

¹Berman, S.M., and Claridge, D.E., "The Positive Aspects of Solar Heat Gain Through Architectural Window Systems" in Energy Conservation and Window Systems, ed. by Samuel M. Berman, et al (Springfield, VA: U. S. Department of Commerce, National Technical Information Service, PB 243 117, April, 1975), p. 62.

FIGURE C.2

AUGUST 21

ORIENTATION OF THE REAR ELEVATION:

NORTH

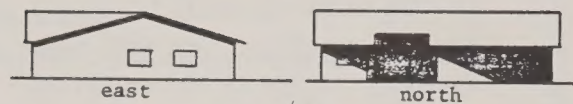
EAST

HEAT GAIN FOR THE ENTIRE DAY:

unshaded glass	83,489 BTU
shaded glass	29,524
total	113,013 BTU

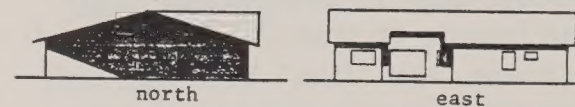
HEAT GAIN FOR THE ENTIRE DAY:

unshaded glass	145,770 BTU
shaded glass	33,427
total	179,197 BTU



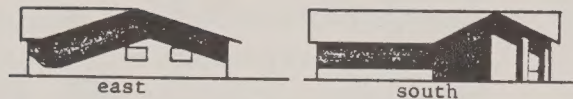
7am

unshaded glass	8,175 BTUH
shaded glass	762
total	8,937 BTUH



7am

unshaded glass	22,920 BTUH
shaded glass	1,010
total	23,930 BTUH



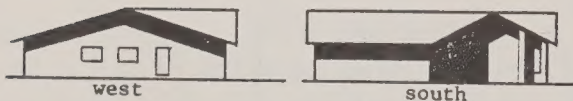
11am

unshaded glass	4,946 BTUH
shaded glass	3,388
total	8,334 BTUH



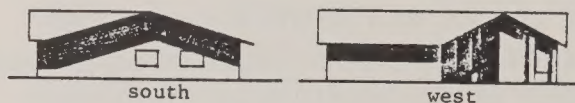
11am

unshaded glass	6,528 BTUH
shaded glass	2,846
total	9,374 BTUH



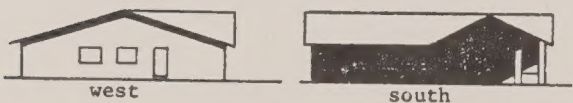
2pm

unshaded glass	6,509 BTUH
shaded glass	2,876
total	9,385 BTUH



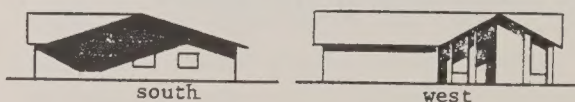
2pm

unshaded glass	6,776 BTUH
shaded glass	3,470
total	10,246 BTUH



4pm

unshaded glass	7,313 BTUH
shaded glass	1,577
total	8,890 BTUH



4pm

unshaded glass	10,406 BTUH
shaded glass	3,126
total	13,532 BTUH

AUGUST 21

SOUTH

ORIENTATION OF THE REAR ELEVATION:

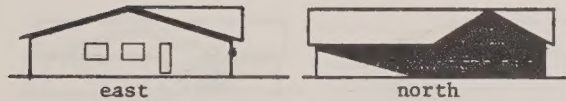
WEST

HEAT GAIN FOR THE ENTIRE DAY:

unshaded glass	104,088 BTU
shaded glass	25,448
total	129,536 BTU

HEAT GAIN FOR THE ENTIRE DAY:

unshaded glass	157,085 BTU
shaded glass	27,192
total	184,277 BTU



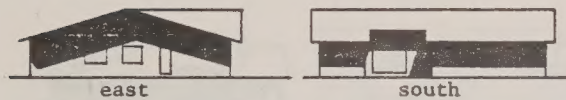
7am

unshaded glass	6,303 BTUH
shaded glass	816
total	7,119 BTUH



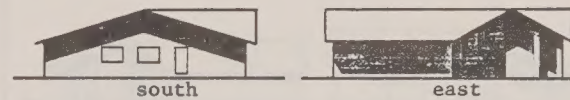
7am

unshaded glass	13,303 BTUH
shaded glass	1,679
total	14,982 BTUH



11am

unshaded glass	9,738 BTUH
shaded glass	3,045
total	12,783 BTUH



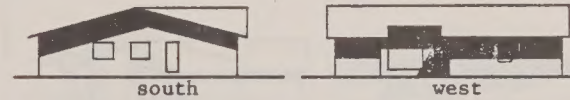
11am

unshaded glass	4,520 BTUH
shaded glass	2,745
total	7,265 BTUH



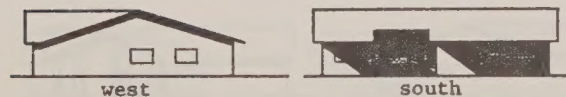
2pm

unshaded glass	10,157 BTUH
shaded glass	2,936
total	13,093 BTUH



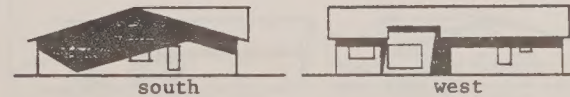
2pm

unshaded glass	14,016 BTUH
shaded glass	2,754
total	16,770 BTUH



4pm

unshaded glass	9,152 BTUH
shaded glass	1,673
total	10,825 BTUH



4pm

unshaded glass	25,853 BTUH
shaded glass	1,375
total	27,228 BTUH

FIGURE C.4

DECEMBER 21

ORIENTATION OF THE REAR ELEVATION:

NORTH

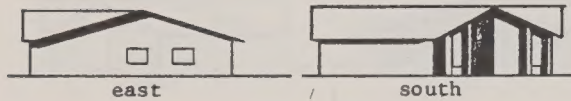
EAST

HEAT GAIN FOR THE ENTIRE DAY:

unshaded glass	100,686 BTU
shaded glass	20,801
total	121,487 BTU

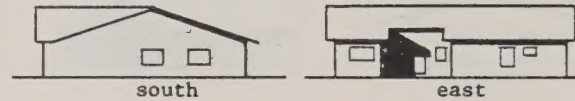
HEAT GAIN FOR THE ENTIRE DAY:

unshaded glass	97,238 BTU
shaded glass	13,464
total	110,702 BTU



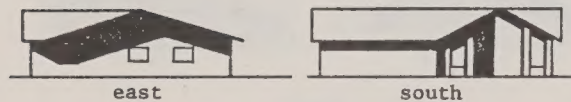
8am

unshaded glass	5,602 BTUH
shaded glass	922
total	6,524 BTUH



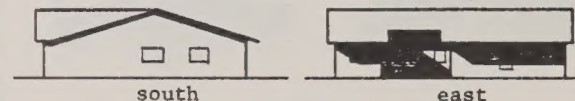
8am

unshaded glass	9,792 BTUH
shaded glass	946
total	10,648 BTUH



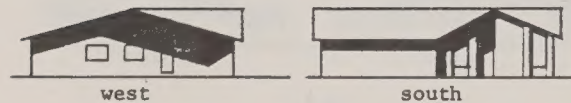
11am

unshaded glass	13,810 BTUH
shaded glass	2,898
total	16,708 BTUH



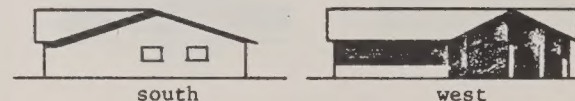
11am

unshaded glass	11,208 BTUH
shaded glass	1,770
total	12,978 BTUH



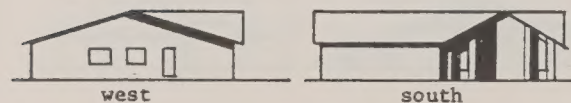
1pm

unshaded glass	13,056 BTUH
shaded glass	2,973
total	16,029 BTUH



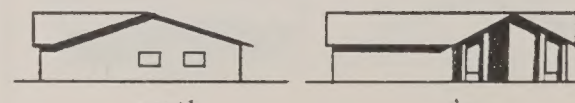
1pm

unshaded glass	10,164 BTUH
shaded glass	1,662
total	11,826 BTUH



3pm

unshaded glass	11,550 BTUH
shaded glass	1,993
total	13,543 BTUH



3pm

unshaded glass	12,232 BTUH
shaded glass	1,828
total	14,060 BTUH

FIGURE C.5

DECEMBER 21

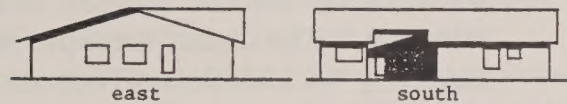
ORIENTATION OF THE REAR ELEVATION:

SOUTH

WEST

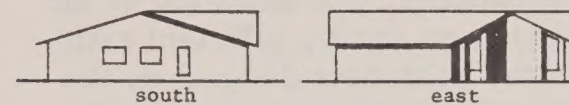
HEAT GAIN FOR THE ENTIRE DAY:
 unshaded glass 180,793 BTU
 shaded glass 15,296
 total 196,089 BTU

HEAT GAIN FOR THE ENTIRE DAY:
 unshaded glass 88,255 BTU
 shaded glass 15,219
 total 103,474 BTU



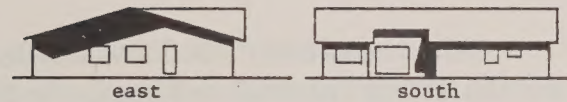
8am

unshaded glass 6,615 BTUH
 shaded glass 979
 total 7,594 BTUH



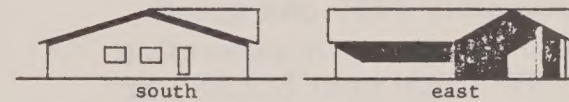
8am

unshaded glass 5,541 BTUH
 shaded glass 1,110
 total 6,651 BTUH



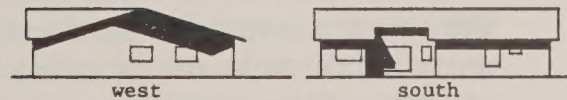
11am

unshaded glass 28,234 BTUH
 shaded glass 1,581
 total 29,815 BTUH



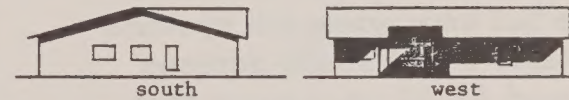
11am

unshaded glass 7,986 BTUH
 shaded glass 1,689
 total 9,675 BTUH



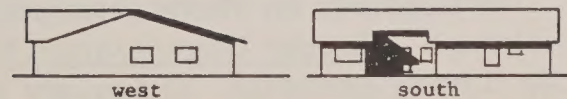
1pm

unshaded glass 28,398 BTUH
 shaded glass 1,626
 total 30,024 BTUH



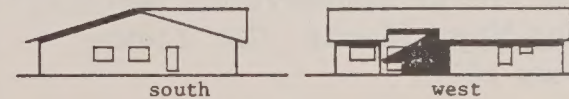
1pm

unshaded glass 9,262 BTUH
 shaded glass 1,749
 total 11,011 BTUH



3pm

unshaded glass 16,728 BTUH
 shaded glass 2,244
 total 18,972 BTUH



3pm

unshaded glass 15,088 BTUH
 shaded glass 2,042
 total 17,130 BTUH

Another study¹ by Living Systems found that for a typical house in the Central Valley climate, every 55 square feet of unshaded west-facing window in the house will increase the peak air conditioning demand by approximately one ton.

Since the peak hour for electrical demand in this area corresponds to the peak demand for residential air conditioning, one extra ton of air conditioning (assuming an energy efficient ratio of 6) will increase the peak hour demand on the electrical utility system by approximately 2 KW. Living Systems defines the choices:

"... we can buy an additional ton of air conditioning for the house at a cost of approximately \$250 and spend around \$2000 to increase our generating capacity by 2 KW (total cost \$2250), or we can take steps to eliminate the solar radiation coming through the windows. The cost of shading a window using a moveable insulation system would run around \$5.00 per square foot; somewhat less effective but very adequate systems such as moveable metal shade screens would run around \$1.50 per square foot installed. The old standby of bamboo screen hanging from an eave would cost

about 25 cents per square foot. Thus the cost of eliminating the solar radiation runs from a high of \$275 to a low of \$13.75. Even with the most expensive shading device, the first cost of shading a window is only one-eighth the cost of providing the air conditioning to make up for the impact of an unshaded window. The least expensive shading strategy is 169 times less expensive than providing air conditioning. This is a specific case, yet it is one which repeats itself hundreds of thousands of times in residential and commercial buildings throughout the state."

Other research² in Davis related to orientation and building thermal response indicated east and west-facing apartments use much more energy for cooling than north or south-facing units (see Figure C-6).

"In fact, east-facing windows are the worst, since the air conditioning units click on in the morning and run all day. Even with air conditioning, east or west-facing, top story apartments remained the coolest in the summer, especially those on the bottom story."

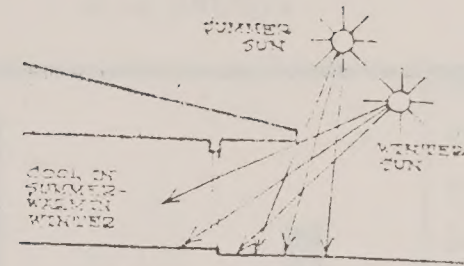
¹"A Plan For An Energy Conservation Service," Energy Conservation News (Davis, CA: Living Systems), 23 January 1976.

²"Research on Thermal Response of Davis Buildings," Energy Conservation News (Davis, CA: Living Systems), 23 January 1976.

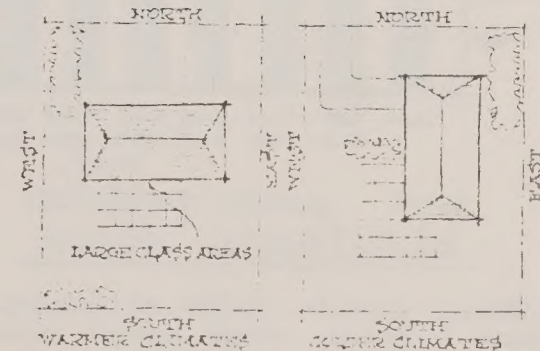
A winter study similar to the summer study indicated that south-facing apartments with good sun exposure are significantly warmer during the winter (see Figure C-7). The researchers reported that during several days the high temperatures in vacant south-facing apartments were 24°F. above ambient while only 17° above ambient in units facing north, east or west. The units, selected at random, were built without regard to solar exposure and were far from ideal for that purpose. By comparison, a specially-constructed research room with nearly ideal south window exposure registered an interior maximum temperatures 48°F. above the maximum ambient.

The David researchers concluded that:

"It is clear from the results of the experiments on Davis apartments that the summer heating load from east and west facing windows far exceeds the comfort level and necessitates the use of large amounts of electricity for cooling. In the winter, apartments are warmed by south facing glass windows and require less natural gas for heating than do apartments with predominantly north, east and west facing glass. The data suggests that optimum natural heating and cooling is obtained with well-ventilated buildings oriented north-south with the maximum glass exposure on the south side."



Correctly designed overhangs shield walls from the summer sun and expose them in the winter.



We should orient houses with wind and sun in mind.

FIGURE C-6

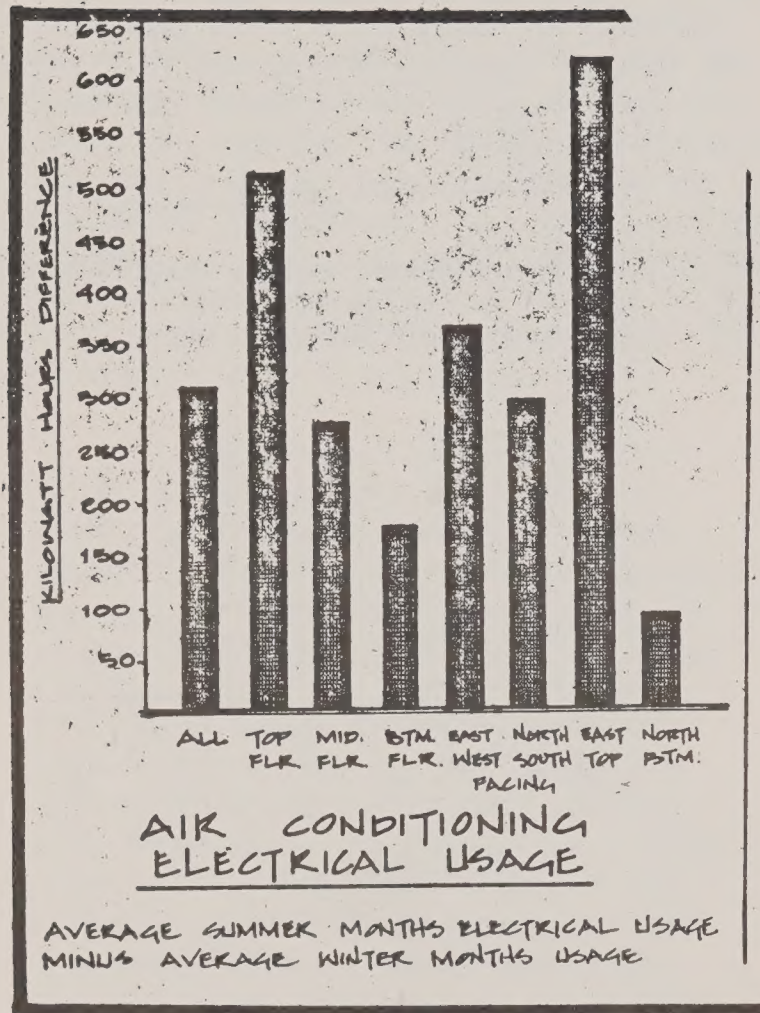
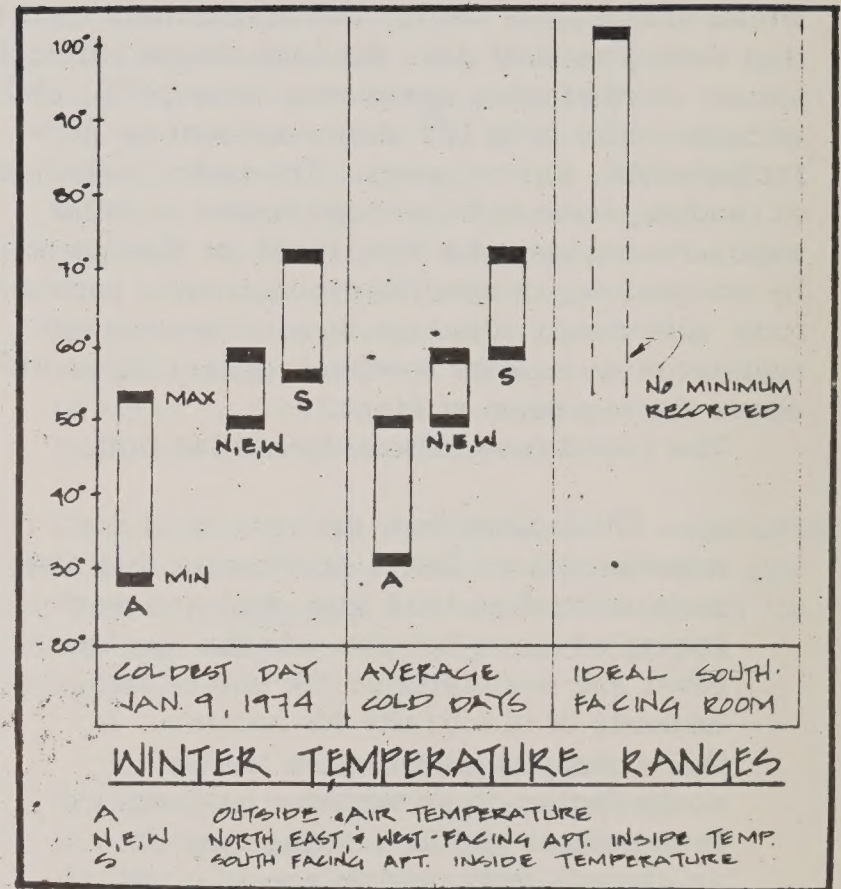


FIGURE C-7



Source: Hammond, Johnathon; Hunt, Marshall; Cramer, Richard; and Neubauer, Loren, A Strategy for Energy Conservation (Davis, CA: The City of Davis), pp. 10 and 14.

GLOSSARY OF TERMS
ENERGY CONSERVATION IN BUILDINGS
AND LAND USE PLANNING

Absorption water chiller: A water chiller that uses heat as its prime source of energy. It has no moving parts (it does not use a compressor), but is less efficient than an electrically-driven chiller.

Air Conditioning: The process of treating air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet requirements of the conditioned space.

ASHRAE: American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.

Aspect: The direction that a surface faces, as in a southern aspect of a hillside.

Automatic: Self-acting, operating by its own mechanism when actuated by some impersonal influence, as for example, a change in current strength, pressure, temperature, or mechanical configuration.

Balance temperature: The outdoor temperature at which the internal heat gain of a building (from lighting, people, and machines) equals the losses through walls, roof and windows.

Ballast: A device used with gaseous discharge lamps and tubes to limit current flow and to provide voltage control at proper design levels.

Block load: Preliminary heat loss and heat gain calculations for a complete building.

Boiler capacity: The amount of heat output in BTU/HR at the design temperature/rise and rated output.

BTU: British thermal unit, or the amount of heat required to raise one pound of water through one degree F.

BTUH: British thermal units per hour.

Build-out factor: As used in this study, the ratio of actual energy demand units to the maximum possible number of energy demand units over a given base period, where an energy demand unit is one land use element (such as a residence) consuming energy for one year. A build-out factor is used to reflect the delayed effect of land use decisions. For example, if a subdivision will not be fully occupied for five years, there will be vacant lots during this initial period which will not be creating a demand for fuels. Over a 20-year base period of calculating energy use, the build-out factor would be 0.9. The subdivision would thus consume only 90% of the energy that would have been needed if the project would have been "built-out" immediately.

Building envelope: The "skin" of a building which encloses conditioned spaces through which thermal energy may be transferred to or from the exterior.

Building transformer: Means of reducing high transmission voltages to lower utilization voltages (100 volts).

Capacitor: A device that stores an electric potential. Applied to power factors, it restores correct phasing of current and voltage.

Coefficient of performance (COP)—cooling: The ratio of the rate of net heat removal to the rate of total energy input, expressed in consistent units and under designated operating conditions.

Coefficient of performance (COP)—heat pump, heating: The ratio of the rate of useful heat delivered by the complete heat pump unit (exclusive of supplementary heating) to the corresponding rate of energy input, in consistent units and under designated operating conditions.

C.F.M.: Standard cubic feet per minute.

Contrast: The relationship between the luminances of an object and its immediate background.

Cooling load: Work load of an air conditioning unit.

Cooling pond: A large body of water that loses heat by evaporation from its surface. The rate of heat loss can be increased by agitation or the installation of spray devices.

Condenser: Part of a refrigeration machine where heat is extracted from hot refrigerant gas for rejection from the building or machine.

C.U.: Coefficient of utilization.

Cul-de-sac: A "dead-end" street of limited length.

Degree day, heating: A unit, based upon temperature difference and time, used in estimating fuel consumption and specifying nominal heating load a building in winter. For any one day, when the mean temperature is less than 65F., there exists as many degree days as there are Fahrenheit degrees difference in temperature between the mean temperature for the day and 65F.

Design conditions: Selected outdoor conditions, which predict the maximum and minimum temperatures to which a building will be subjected. Also, outdoor temperature conditions selected to maintain occupants' comfort.

Direct energy input: As used in this study, direct energy inputs refer to fuel actually consumed at the point of use, such as the quantity of natural gas used to heat a home.

Disability glare: Spurious light from any source, which gets into a viewer's eyes and impairs his ability to discern a given object.

Double-bundle condenser: A condenser that contains two sets of heat-extracting coils. One set is used to reclaim waste heat when it can be used; the other set of coils is used to reject waste heat when it cannot be used.

Double-bundle evaporator: An evaporator that contains two sets of heat exchange coils. One set is used to provide chilled water during normal machine operation and the other set acts as low-temperature heat input when the machine is used as a heat pump.

Dry bulb temperature: The measure of the sensible temperature of air.

Dual duct system: Ventilation system that uses two separate ducts to each outlet. One duct supplies hot air and the other supplies cold air. Mixing the two airstreams at the outlets provides the desired temperature.

Economizer cycle: Ventilation system that uses cool, outdoor air, whenever possible, to offset heat gains in the building rather than using a refrigeration machine, which requires electrical energy to drive it.

Energetics: The science of the laws of energy.

Energy component: The section of an environmental impact report which deals with the energy impact of a project; required under California law.

Energy demand unit: As used in this study, one land use element, such as a residence, consuming energy for one year.

Energy efficiency ratio (EER): The ratio of net cooling capacity in BTU/H to total electric input in watts under designated operating conditions.

Energy flow diagram: A schematic diagram for depicting energy flows.

Energy performance index or indices (EPI): Energy budgets for lighting, heating, cooling, total and other uses including cooking, water heating, etc.

Electric demand limiter: A device that turns off or reduces the power to electrically-powered equipment whenever the total electrical load rises to a predetermined level.

E.P.I.: Energy performance index or indices.

Energy source: The raw energy at the source which is as the hole in the ground, oil or gas wells.

E.S.I.: Equivalent spherical illumination.

Evaporator: Part of a refrigeration machine where cold refrigerant liquid absorbs heat from some of the medium (water) to provide a cooling effect.

Fan coil: A heating device that blows air through a hot radiator coil.

Foot-candle: Intensity of light at a distance of one foot from a standard (sperm oil) candle.

Glare: The sensation produce by luminance within the visual field that is sufficiently greater than the luminance to which eyes are adapted to cause annoyance, discomfort, or loss in visual performance or ability.

Gross interior floor area: The horizontal projection of that portion of interior space which is served directly or indirectly by an energy-using system, excluding canopies and spaces not cooled or heated.

Heated space: Space, within a building, which is provided with a positive heat supply to maintain a minimum air temperature of 50F.

Heat gain: As applied to HVAC calculations, it is that amount of heat gained by a space from all sources, including people, lights, machines, sunshine, etc. The total heat gain represents the amount of heat that must be removed from a space to maintain desired indoor conditions.

Heat loss: The sum cooling effect of the building structure when the outdoor temperature is lower than the desired indoor temperature. It represents the amount of heat that must be provided to a space to maintain indoor comfort conditions.

Heat pump: A refrigeration machine that can also work in a reverse cycle. In its heating mode, a heat pump absorbs low-temperature heat and raises its temperature to usable levels. The low-temperature heat can be obtained from many sources, including air and water, and can be used in different ways, such as heating air or water. An air-to-air heat pump is one that takes heat from low-temperature outdoor air and transmits it at a higher temperature to indoor air. There are also air-to-water, water-to-air, and water-to-water heat pumps; the first word refers to the heat source; the second to the end use.

Heat sink: A body (water, earth, metal, etc.) capable of accepting and storing heat. It can also serve as a heat source.

Heating load: Work load on a heating unit.

Heat redistribution system: A system which transfers excess heat from one zone of a building to another zone which requires heat, as from the interior zone to the perimeter zone. This usually minimizes the total energy required for heating.

HVAC: Heating, ventilating and air conditioning.

HVAC system: A system that provides either collectively or individually the processes of comfort heating, ventilating and/or air conditioning within or associated with a building.

I.E.S.: Illuminating Engineering Society.

Indirect energy input: As used in this study, indirect energy input refers to the "hidden" energy which is built into a fuel, product or service before the point of use, such as the fuel consumed in producing a brick or a gallon of gasoline.

Infiltration: The uncontrolled inward air leakage through cracks and interstices in any building element and around windows and doors of a building, caused by the pressure effects of wind and/or the effect of differences in the indoor and outdoor air density.

Initial energy input: As used in this study, initial energy input refers to the energy used for constructing "front-end" improvements in urban development, such as the streets in a subdivision.

Interior zone: In a multistory building, the interior space beginning about 15 feet from the outside wall and including all floors except the top.

Internal travel distance: As used in this study, internal travel distance refers to the total distance traveled within a residential project if one resident of each unit would make one trip to an established point or points at the perimeter of the project.

Kilocalorie: One thousand calories, where a calorie is the quantity of heat required to raise the temperature of one gram of water one degree centigrade.

K.W.H.: Kilowatt-hour, a unit of energy equivalent to that transferred or expended by one kilowatt of power.

Lamp: A generic term for a man-made source of light.

Latent heat: The change in heat quantity that occurs without any corresponding change in temperature. Usually accompanied by a change of state; for example, water may change to steam, or the moisture content in air may be increased.

Leapfrog development: Haphazard urban expansion into areas beyond the existing city fringe, with substantial vacant land closer to city services and facilities available as alternate sites for development.

Load-shedding device: A mechanical contrivance that will enable the load of a machine to be reduced on demand.

Long-term energy input: As used in this study, long-term energy input refers to continuing energy requirements spaced out over a period of time, such as on-going fuel use for home heating.

Loop-type heat pump: A system that circulates water through a closed-pipe loop (common to many heat pumps) that can either take heat from the loop or reject heat back into the loop according to working conditions. When simultaneous heating and cooling loads occur in a building, this system can collect unwanted heat from cooling one space and use it to heat another space.

Lumen: Measure of light intensity; one lumen per square foot equals one foot-candle.

Luminaire: Light fixture designed to produce a special effect.

Multizone system: A HVAC control air-handling unit that provides hot and cold air and facilities for mixing these at the unit to give different supply temperatures to a number of zones.

Nonuniform lighting: Task lighting only where needed within a space, in contrast to task lighting levels provided generally through the space.

Occupied hours: The time when a commercial, industrial or institutional building is occupied.

New energy: Electrical or chemical energy converted to thermal or mechanical energy expressly for the purpose of heating and cooling.

Office landscaping: Architectural treatment of large, open interior spaces designed to provide privacy while retaining the benefits of open planning. Eliminates most floor-to-ceiling partition systems.

Peak load: Maximum predicted demand for any system.

Power: The rate of flow of useful energy; energy transferred per unit of time.

Power factor: Relationship between the theoretical kv.-a (kilovolt times ampere) versus the actual kilowatt power used. When the power factor is unity, or equal 1, kv.-a equals kw. This is the ideal situation and can be achieved by installing capacitors on the inductive circuits.

Power-factor correcting condenser: See capacitor.

Prime mover: Source of motive energy; for example, an electric motor, diesel engine, etc.

Quad: One quadrillion BTU's.

Raw source energy: Tracing an energy system back to its original source.

Recovered energy: Energy utilized which would otherwise be wasted from an energy utilization system.

Reheat: The application of heat to air after it has been cooled.

Refrigeration machine: A device that uses energy to extract heat from a fluid or gas, thereby cooling it.

Run-around coil: System of piping and heat transfer coils used to transfer unwanted heat from one source for use in another area.

Sensible heat: Heat that results in a change in temperature (as opposed to latent heat) and that can be "sensed," or felt.

Setback temperature (or night setback): In the interest of economy and energy use, temperature in the winter may be set back to 60°F. during the unoccupied hours instead of maintaining 68°F., as during occupied hours.

Solar load: The quantity of unwanted heat that is directly attributable to the sun shining on the surface or through the windows, etc., of a building, thereby increasing interior temperatures.

Solar energy source: Source of thermal, chemical or electric energy derived directly from conversion of incident solar radiation.

Space heating: Interior heating system for a building.

Static luminaire: A conventional lighting fixture having no air flow (other than normal convection) through the lamp compartment.

Subdivision: As used in this study, a subdivision refers to the dividing of a property into two or more lots, together with necessary construction of streets and utilities. No distinction is made in this study between property divisions of less than five lots (often called a lot division) and "major" subdivisions of five or more lots. The term "subdivision" is often loosely used to describe a housing project built by a developer, including both building construction and property division.

Sun time: A time related directly and exclusively to the position of the sun. For example, noon occurs when the sun is due north. There are variations in different longitudes.

Terminal reheat system: A ventilation system that cools air down to a constant condition regardless of load and then reheats it to meet building requirements. Probably the most inefficient HVAC system.

Therm: One hundred thousand BTU's.

Thermal wheel: A device for use in ventilating systems that enables waste heat to be captured from exhaust air and then transferred to warm, incoming air.

Thermal transmission: The rate at which heat passes through a material and is directly proportional to the U value and the temperature differential across the material.

Total energy: On-site electrical generating plant with the capacity to recover and reuse its own waste heat. Total energy systems can operate at up to 75 per cent efficiency.

U value: A measure of energy (BTU) that passes through a square foot of structure for every degree of difference between indoor and outdoor temperatures.

Unitary air conditioner: One or more factory-made assemblies which normally include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function as well. Where such equipment is provided in more than one assembly the separate assemblies shall be designed to be used together.

Unoccupied hours: The time when a commercial, industrial or institutional building is normally empty of people, except for a few attendants or maintenance personnel.

Utility infrastructure: As used in this study, utility infrastructure refers to the network of storm sewers, sanitary sewers, water lines, and other utility lines necessary to serve urban development.

V.A.V.: Variable air volume.

Variable volume system: A ventilating system that operates at a constant temperature and varies the volume of air supplied to any space in accordance with its heating or cooling requirements.

Veiling reflection: Reflection of light from a task, or work surface, into the viewer's eyes.

Ventilation air: That portion of supply air which comes from outside (outdoors) plus any recirculated air that has been treated to maintain the desired quality of air within a designated space.

Watt: A unit of electric power or heat power. One watt equals 3.4 BTU/HR.

Wet bulb temperature: The lowest temperature attainable by evaporating water in the air without the addition or subtraction of energy (adiabatic saturation).

Work area: Circulation area within work space but not at work station.

Work station: Space (such as a desk top) where task is actually being performed.

Zero-lot-line regulations: Zoning of property which allows a building to extend to the property line or one or more sides.

Zone: A space or group of spaces within a building with heating and/or cooling requirements sufficiently similar so that common control of the heating and/or cooling capacity by a single device can provide comfort conditions throughout.

APPENDIX E

CONVERSION FACTORS

USED IN ENERGY CONSERVATION PLANNING

WHAT IS A BTU?

A BTU is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

Since the BTU is a very small unit of measurement, the energy tables used in this report are expressed in large multiples such as 1,000 BTU (10^3). Other common multiples include the therm (100,000 BTU or 10^5 BTU) and the quad (1,000,000,000,000 BTU or 10^{12} BTU).

The BTU equivalents of common fuels are shown in Table E-1 below:

TABLE E-1
BTU EQUIVALENTS OF COMMON FUELS

Fuel	Common Measure ¹	BTU
Crude Oil	Barrel (Bbl.)	5,800,000
Distillate Fuel	Barrel (Bbl.)	5,800,000
Residual Fuel	Barrel (Bbl.)	6,300,000
Gasoline	Barrel (Bbl.)	5,300,000
Natural Gas (dry)	Cubic Foot (scf)	1,032
Natural Gas (liquid)	Barrel (Bbl.)	4,100,000
Coal (average)	Ton	25,000,000
Electricity	Kilowatt Hour (KWH)	3,412
Fissionable Material ²	Gram (gm.)	74,000,000

¹One Barrel (Bbl.) = 42 gallons.

²U-235 fission with 192 MeV per fission.

APPROXIMATE CONVERSION FACTORS FOR CRUDE OIL¹

From—	Into—						
	Metric tons	Long tons	Short tons	Barrels	Kiloliters (cubic meters)	1,000 gallons (Imperial)	1,000 gallons (U.S.)
Metric tons.....	1	0.984	1.102	7.33	1.16	0.256	0.308
Long tons.....	1.016	1	1.120	7.45	1.18	.261	.313
Short tons.....	.907	.893	1	6.65	1.05	.233	.279
Barrels.....	.136	.134	.150	1	.159	.035	.042
Kiloliters (cubic meters).....	.863	.849	.951	6.29	1	.220	.264
1,000 gallons (Imperial).....	3.91	3.83	4.29	28.6	4.55	1	1.201
1,000 gallons (U.S.).....	3.25	3.19	3.58	23.8	3.79	.833	1

¹ Based on world average (excluding natural gas liquids).

COMPARISON OF HEATING COSTS FOR ELECTRICITY AND NATURAL GAS

DEFINITIONS

A Kilowatt Hour (KWH) is 1,000 watt hours of electrical power.

A British Thermal Unit (BTU) is the amount of heat required to raise the temperature of one pound of water from 59°F. to 60°F. A Therm is 100,000 BTU.

The Heat Equivalent of 1 KWH is equal to 3,413 BTU or .03413 Therms.

COMPARISONS

Electricity is converted into heat of resistance (the most common type of electrical heating) at close to 100 per cent efficiency at the building site. If the heat value of electricity is .03413 Therms and the cost is \$0.033 per KWH, then the equivalent electrical cost of one therm of delivered heat is \$0.97.

$$(1) \quad 1 \text{ KWH} \div .03413 \text{ Therms} = 29.299 \text{ KWH/Therm}$$

$$(2) \quad 29.30 \text{ KWH/Therm} \times \$0.033/\text{KWH} = \$0.97/\text{Therm of Electrical Heat}$$

Much of the heat from burning gas escapes up the flue resulting in overall efficiencies of not more than 70 per cent. Therefore, it takes approximately 1.428 Therms of gas burned to deliver 1.0 Therms of useable heat to the building.

$$(3) \quad 1.0 \text{ Therms (output)} \div .70 = 1.428 \text{ Therms (input)}$$

At \$0.172 per Therm, the cost of one therm of useable heat is approximately \$0.246.

$$(4) \quad \$0.172/\text{Therm (input)} \times 1.428 = \$0.246/\text{Therm (output)}$$

In this example, the cost of electrical resistance heating is approximately 3.94 times greater than the cost of delivering the same amount of heat using gas.

$$(5) \quad \$0.97/\text{Therm (electrical)} \div \$0.246/\text{Therm (gas)} = 3.94$$

and

$$(6) \quad \$0.172/\text{Therm (gas)} \times 3.94 = \$0.68/\text{Therm (electric equivalent)}$$

Conversely, the electrical equivalent of one Therm of gas purchased from the utility for heating is only 20.51 KWH.

$$(7) \quad 0.7 \text{ efficiency} \times 29.30 \text{ KWH/Therm (direct equivalent)} = \\ 20.51 \text{ KWH/Therm (gas equivalent)}$$

The per Therm cost equivalent of electrical power may be derived by multiplying the cost per KWH by 20.51. Using the costs in the example, the equivalent cost of one Therm of electrical power for heating is \$0.68.

$$(8) \quad \$0.033/\text{KWH} \times 20.51 \text{ KWH/Therm} = \$0.68/\text{Therm (electric equivalent)}$$

NOTES:

Fuel costs for the above comparisons were extracted from examples on the Notice for Public Hearings for PG and E Rate Change Application No. 55509 and 55510 which include recognition of the "Lifeline" policies. Rates are based on gas usage of 122 Therms per month and electrical usage of 534 KWH per month.

IV. CONVERSION FACTORS

<u>To Convert</u>	<u>Into</u>	<u>Multiply by</u>
acres	square feet	43,560
acres	square meters	4,047
angstroms	meters	1×10^{-10}
British Thermal Units(BTU)	Calories	252
BTU	joules	1,055
BTU	KWH	2.93×10^{-4}
BTU	Megawatt-years	3.34×10^{-11}
BTU/sq. ft.	Langleys (cal/cm ²)	0.271
Calories (Cal.)	BTU	3.97×10^{-3}
Calories	foot-pounds	3.09
Calories	joules	4.18
Calories/minute (cal/min)	Watts	0.0698
Centimeters (cm)	inches	0.394
feet (ft.)	meters	0.305
foot-pounds (ft-lbs)	calories	0.324
foot-pounds	joules	1.36
foot-pound	kilogram-meters	0.138
foot-pounds	KWH	3.77×10^{-7}
gallons (gal.)	Liters	3.79
gallons	Pounds	0.00220
GGj	BTU	0.95×10^{15}
Gigawatts (GW)	watts	1×10^9

<u>To Convert</u>	<u>Into</u>	<u>Multiply by</u>
horsepower (hp)	kilowatts	0.745
joules	BTU	9.48×10^{-4}
joules	calories	0.239
joules	foot-pounds (ft-lbs)	0.738
joules	Watt-hours	2.78×10^{-4}
1000 calories (Kcal)	BTU	3.97
Kcal/minute	kilowatts	0.0698
kilogram-meters	foot-pounds	7.23
kilograms (Kg)	pounds	2.20
kilograms	tons	0.00110
kilowatts (KW)	horsepower	1.34
kilowatt-hours (KWH)	BTU	3,413
kilowatt-hours	foot-pounds	2.66×10^6
kilowatt-hours	watt-hours	1×10^3
kilowatts	Kcal/min	14.3
langleys	BTU/sq. ft.	3.69
Langleys/min	watts/sc cm	0.0698
Megawatt-hours	BTU	3.41×10^6
Megawatt-years	BTU	2.99×10^{10}
Microns	meters	1×10^{-6}
Miles	meters	1,609
square centimeters (sq cm)	sq. ft.	0.00108
sq. cm	sq.in.	0.155
square feet (sq. ft.)	sq. in.	144

<u>To Convert</u>	<u>Into</u>	<u>Multiply by</u>
sq. ft.	sq. m	0.0929
square inches (sq. in.)	sq. cm	6.45
square meters (sq m)	sq ft	10.8
sq m	sq mi	3.86×10^{-7}
square miles (sq mi)	acres	640
sq mi	sq ft	2.79×10^7
sq mi	sq m	2.59×10^6
tons (short)	Kg	907
tons (short)	lb	2000
tons (metric)	tons (short)	1.1025
tons (short)	tons (metric)	0.907
Watt-hours	joules	3600
$^{\circ}\text{Fahrenheit}$	$^{\circ}\text{Centigrade}$	subtract 32 and multiply by 0.555
$^{\circ}\text{Centigrade}$	$^{\circ}\text{Fahrenheit}$	multiply by 1.8 and add 32
cal per sq cm-sec $^{-\circ}\text{C}$	BTU per sq ft-hr- $^{\circ}\text{F}$	7380
BTU per sq ft -hr - $^{\circ}\text{F}$	Cal per sq cm -sec - $^{\circ}\text{C}$	1.35×10^{-4}

Bibliography

ENERGY OVERVIEWS

Clark, Wilson. *Energy for Survival: The Alternative to Extinction*. New York: Anchor Books, 1975. \$4.95.

A well-documented overview of the energy issue covering background of the problem; limiting factors to growth; energy use in industry, transportation, agriculture and buildings; utility systems; future resources; solar power; and wind power. Heavy emphasis on the need to develop alternative energy sources particularly solar on a decentralized basis. An interesting short afterword that discussed "natural" and "adaptive" architecture.

Committee on Resources and Man, National Academy of Sciences/National Research Council. *Resources and Man*. San Francisco: W. H. Freeman & Co., 1969. \$2.95.

An excellent look at the resources picture (both fuels and ores) which focuses both on near and long-term prospects. This report was written well before the politicization of the energy issue in the early 1970's. And has a concise non-hysterical way of outlining the magnitude of the entire resources picture. The document observes that we will be in very serious trouble with non-renewable mineral resources in the next several decades unless some sort of advance planning is done.

Energy and Power. Scientific American Reprint Series. San Francisco: W. H. Freeman & Co., 1971. \$3.50.

A reprint of 11 articles that appeared in the September 1971 issue of *Scientific American* dedicated to a detailed discussion of energy and power. The book places the energy consumption of civilization in a long-term perspective—past, present and future—and places the subject in a scientific context. An excellent overview of energy heavily-illustrated with photographs and charts. Not as broad in scope as *Energy for Survival* but gives specific subjects a greater depth of treatment.

Patterns of Energy Consumption in the United States. Washington, D.C.: Office of Science and Technology, Executive Office of the President, 1972. \$2.95. (Available from U.S. Government Printing Office, Washington, D.C. 20402, Stock Number 4106-0034).

Presents findings of a study by the Stanford Research Institute on trends of energy consumption since 1960. Broken down by broad categories—residential, commercial, industrial, transportation—and by specific end uses within each sector. No projections of future energy demands are made, nor are there any observations regarding energy policy. Over 125 tables and charts are included.

Wilson, Mitchell, and editors of *Life*. *Energy*. New York: Time, Inc., 1963. \$5.95.

An excellent overview of energy covering what it is, its many forms, and its relation to the progress of civilization throughout history. Written in non-technical terms and profusely illustrated. A part of the Time-Life Science Library.

ENERGY AND PUBLIC POLICY

A National Plan for Energy Research, Development and Demonstration.

Washington, D.C.: Energy Research and Development Administration, 1975. Vol. 1, \$1.70; Vol. 2, \$2.45. (Available from U. S. Government Printing Office, Washington, D.C. 20402.)

Two volumes outline ERDA's national plan for energy development. Volume 1, the plan itself, details national energy problems, states energy technology goals, poses possible scenarios for future energy systems, sets priorities for energy goals. Volume 2 describes program for achieving the goals of energy plan.

A Nation of Energy Efficient Buildings by 1990. Washington, D.C.: The American Institute of Architects, February 1975. (Available from Publications Marketing, The American Institute of Architects, 1735 New York Avenue, N.W., Washington, D.C. 20006, single copies free.)

The second energy report of the AIA further develops the strategy generated in the first energy report. It develops the thesis that converting existing buildings to energy efficiency and producing new energy efficient buildings is a wiser course in a capital and energy scarce era than simply striving to increase energy production. The economic and financial feasibility of the strategy is then shown. Also outlined is a possible implementation concept involving a new form of energy utility that would have a vested interest in helping to create and maintain energy-efficient buildings through the use of decentralized energy systems.

A Time to Choose. Final Report of Ford Foundation's Energy Policy Project. Cambridge, Mass.: Ballinger Publishing Co., 1974. \$3.50.

Principal finding is that the U.S. can balance its energy budget, control pollution, and avoid reliance on insecure oil sources abroad by slowing its growth rate in energy consumption. Introduces energy policy and discusses three alternative future energy scenarios. Discusses the American energy consumer. Relates energy, employment and economic growth; energy and the environment; U.S. energy policy in the world context; private enterprise and the public interest. Suggests reforming electric utility regulation. Outlines energy research and development. Suggests strong governmental role.

Daly, Herman E. "Energy Demand Forecasting: Prediction or Planning?" Journal of the American Institute of Planners, Vol. 42, No. 1, January, 1976, pp. 4-15.

Energy and the Built Environment: A Gap in Current Strategies. Washington, D.C.: The American Institute of Architects, May 1974. (Available from Publications Marketing, The American Institute of Architects, 1735 New York Avenue, N.W., Washington, D.C. 20006, single copies free.)

The First energy report of the AIA establishes a framework for a comprehensive strategy to achieve the full potential of energy savings available in the built environment. The report conceptualizes energy and energy systems; defines energy-efficient buildings, quantifies the potential of energy savings that energy-efficient buildings offer; and begins to evolve a plan to attain that potential. Through a high priority national program to make all buildings energy-efficient, the report shows how the energy equivalent of 12.5 million barrels of oil per day could be saved by 1990.

Energy Conservation Strategies. Washington, D.C.: Office of Research and Monitoring, Environmental Protection Agency, July 1973. \$1.55. (Available from the U. S. Government Printing Office, Locator EPA-R5-73-021.)

Examines various strategies for reducing national energy demand, by (a) modifying energy-wasteful government policies; (b) internalizing environmental costs to users; and (c) assisting the marketplace on a selective basis. Findings suggest that if the government should wish to take an activist position on behalf of energy conservation, a market-based strategy appears attractive. The three most pressing economic questions dealt with are the energy-efficiency of transportation alternatives, the rate structure for electricity, and the burden of and response to increased heating costs. A number of areas are identified where further research is needed on the optimum allocation of scarce energy among users.

Freeman, S. David. Energy: The New Era. New York: Vintage Books, 1974, \$2.45.

Presents many dimensions of the energy problem including demand, environment, available resources, foreign and national policy, economics, and politics. Urges conservation measures, the development of alternative sources of energy, and calls for the development of a comprehensive national policy. The author was the former director of the Ford Foundation's Energy Policy Project.

Gabel, Medard. Energy, Earth and Everyone. San Francisco: Straight Arrow Books, 1975. \$4.95.

In 1974 Buckminster Fuller hosted a World Game Workshop at the Philadelphia University Science Center. This publication documents the results of that event. Consistent with Fuller's approach the study examines energy on a global basis and establishes strategies for its use. An objective is to develop a full range of "income" energy systems within a hydrogen storage and transportation network. A global energy utility is outlined and critical paths are generated for the development of income energy sources. (Nuclear power would be eventually phased out.) Excellent discussions covering history, advantages and disadvantages are offered for 24 forms of energy. The conservation strategy in the building sector is primarily directed toward buildings at the community level.

Gilliam, Harold. "A Rich 'New' Source of U.S. Energy: Save It!" San Francisco Examiner, March 28, 1976, p. 26.

Hayes, Denis. Energy: The Case for Conservation. Worldwatch Paper No. 4. Worldwatch Institute, 1976.

Citizens' Advisory Committee on Environmental Quality. Citizen Action Guide to Energy Conservation. Washington, D.C.: U.S. Government Printing Office, September, 1973. (Stock No. 4000-00300.)

Committee on Science and Astronautics. Report to the 93rd Congress, 2nd Session. Conservation and Efficient Use of Energy. Washington, D.C.: U. S. Government Printing Office, 1974.

Irving, Carl. "Crisis Seen Reshaping Bay Area Future." San Francisco Sunday Examiner and Chronicle, February 24, 1974.

Pacific Gas and Electric Company. The Outlook 1975. San Francisco: Pacific Gas and Electric Company, September, 1974.

Pacific Gas and Electric Company. Saving Energy is Everyone's Concern. San Francisco: December, 1973 (Revised March, 1974.).

Stanford Research Institute. Meeting California's Energy Requirements, 1975-2000. Menlo Park: Stanford Research Institute, May, 1973.

The Potential for Energy Conservation. Washington, D.C.: U. S. Office of Emergency Preparedness, 1972. \$3.00. (Available from the U.S. Government Printing Office, Locator 4102-00009.)

Presents quantitative measures of energy consumption by end use, and offers a program of energy consumption measures along with estimates of the impact of these measures on national energy consumption. Concludes that the most significant energy conservation measures are the installation of improved insulation in both new and old homes; the use of more efficient air conditioners; a shift of intercity freight from trucks to rail, intercity passengers from air to rail and bus, and urban passengers from automobiles to motorized mass transit; and the introduction of more efficient industrial processes and equipment.

ENERGETICS

Herendeen, Robert A. and Bullard, Clark W., III. Energy Cost of Commerce Goods, 1963 and 1967. Urbana-Champaign: University of Illinois, Center for Advanced Computation, November, 1974.

An important and unique source document needed to calculate the energy required to produce or deliver virtually any product or service.

Miller, G.T., Jr. Energetics, Kinetics and Life. Belmont, CA: Wadsworth Publishing Company. \$6.95. (Available from Wadsworth Publishing Company, 10 Davis Drive, Belmont, CA 94022.)

Good introduction to chemical thermodynamics and kinetics using everyday examples in order to impart an intuitive feel and application of this important subject especially as it applies to the energy problem.

Odum, Howard. Environment, Power and Society. New York: Wiley-Interscience, 1971. \$6.95.

The classic introduction to energetics and energy budgets as they relate to human activities.

Real Estate Research Corporation. The Costs of Sprawl, Volumes 1, 2 and 3. Washington, D.C.: U. S. Government Printing Office, April, 1974. (Stock No. 4111-00021.)

A landmark study on the economic costs of various types and densities of residential development which serves as an important source of data for energetics calculations.

Yeang, Ken. "Energetics of the Built Environment." Architectural Design, July, 1974, pp. 446-51.

ENERGY CONSERVATION IN COMMUNITY AND REGIONAL PLANNING

Abrahamson, Dean E. Environmental Cost of Electric Power. New York: Scientists' Institute for Public Information, 1970.

Association of Bay Area Governments. Energy Needs—A New Criterion for Planning? (Discussion Papers for the ABAG General Assembly, February 21, 1974.) Berkeley: ABAG, February 21, 1974.

A Strategy for Energy Conservation: A Proposed Energy Conservation and Solar Utilization Ordinance for the City of Davis, California. Winters, California: Living Systems, 1974. \$5.00 (Available from Living Systems, Route 1, Box 170, Winters, CA 95694.)

Presents a range of actions for implementation into policy and ordinances. These include building standards and neighborhood planning. The building standards proposed use a two-path approach. Path 1 is a set of prescriptive design requirements; Path 2 establishes a performance approach based on a "design day" heat loss or heat gain (192 BTU's heat loss/S.F./day and 48 BTU's heat gain/SF/day). Aspects of neighborhood planning include circulation, use of land, and landscaping. A survey of 78 Davis households yields an interesting set of data on energy consumption and costs. In addition, a survey of existing housing and apartment complexes is presented with respect to specific design and construction features.

Bullard, Clark W., III. Energy and the Regional Planner. Urbana-Champaign: University of Illinois Center for Advanced Computation, May 13, 1974.

Curl, Huldah, ed. Winona, Towards an Energy Conserving Community. Minneapolis: University of Minnesota, 1975.

Dahlin, Dennis. Evaluating Energy Conservation in the Environmental Impact Assessment Process. (Readings for course by Continuing Education in City, Regional and Environmental Planning, University extension, University of California.) Berkeley: April 4, 1975.

Fraker, H., Jr., and E. Schorske. Energy Husbandry in Housing: An Analysis of the Development Process in a Residential Community, Twin Rivers, New Jersey. Report No. 5 of Center for Environmental Studies, Princeton University, December, 1973. (Available from Center for Environmental Studies, D329 Engineering Quadrangle, Princeton, N.J. 08540, single copies free.)

Using a planned unit development in East Windsor, New Jersey, as a case history, this investigation analyzes the complex structure of the development process which produces large tract residential units. It identifies critical points in the process for effectively initiating energy conservation policies. The analysis discovered that the traditional structure and incentives in the development process do not allow the market to operate efficiently or effectively to conserve energy. The developer acts to minimize first costs at the expense of energy conservation, and the home buyer does not weigh life-cycle operating maintenance costs as significant in the decision to buy. Thus, the need is to change the structure and incentives in the development process in order to act in favor of more efficient energy utilization. The recommendations of this report fall into three general categories: educational, financial, and regulatory.

Hammond, Jonathan, et al. A Strategy for Energy Conservation (proposed Energy Conservation and Solar Utilization Ordinance for the City of Davis, California.) Prepared for The City of Davis with the support of The Case Institute, August, 1974.

Knowles, Ralph L. Energy and Form: An Ecological Approach to Urban Growth. Cambridge: The MIT Press, 1974. \$27.50.

An approach is developed for the planning of regions and settlements as well as for individual buildings to take advantage of natural cycles—in particular, the daily and seasonal rhythms of the sun. This is intended to minimize the need for supportive energy to maintain internal temperatures and other variables at desirable and steady levels. In addition to achieving a better equilibrium with nature, the approach promises a much richer diversity of urban form.

Pozzo, Robert J., and James Clarke. A Planner's Handbook on Energy—With Emphasis on Residential Uses. Tallahassee, FL: Florida State Energy Office, 1975. \$4.50. (Available from State Energy Office, 108 Collins Building, Tallahassee, Florida 32304. Make checks payable to State of Florida, Department of Administration.)

As the second fastest growing state in the nation, Florida faces many problems and opportunities in how energy is applied and utilized in its building sector. Basic facts and figures are oriented to Florida, however the approaches are useful and applicable to other areas. Considerable reference is made to work by Egan. Major sections include considerations affecting energy consumption in dwellings (with emphasis on planning and architectural aspects), transportation, legislative alternatives, and environmental factors. Extensive appendix of selected articles, statements, etc.

Village Homes. Preliminary Description of a Proposed Residential Development for Davis, California. (Prepared for presentation to The Davis City Planning Commission.) Davis: Village Homes, December 4, 1973.

SOLAR RIGHTS

Bainbridge, David A. The Case for Solar Rights. Living Systems, 1975.

Harris, William R. Is the Right to Light a California Necessity? Submitted to the California State Assembly Committee on the Judiciary, December 11, 1975.

Eisenstadt, Melvin. Solar Rights.

Robbins, Richard L. Law and Solar Energy Systems: Legal Impediments and Inducements to Solar Energy Systems. Madison: University of Wisconsin Extension, July 11, 1975.

ENERGY CONSERVATION STANDARDS AND CODES

ASHRAE Standard 90-75: Energy Conservation in New Building Design.

New York: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1975.

Establishes requirements and criteria directed toward the design of building envelopes with high thermal resistance, low air leakage, and improved design of mechanical and electrical systems. A three-path approach is used. The initial path establishes a set of mandatory requirements for the building envelope, HVAC equipment, HVAC system design, service water heating, electrical distribution and lighting. Alternative designs are allowed under two alternative paths on systems analysis and solar/wind energy sources. The alternative designs are allowed only if they can be shown to require less energy than the mandatory requirements.

Eberhard, John P. Performance Standards for Energy Use in Buildings, Policy Paper adopted by AIA Board of Directors Energy Committee, August, 1975.

Energy Conservation Manual, Life Cycle Analysis Manual, and Lifecycle Energy Evaluation Technique Manual. Tallahassee: State Department of General Services, 1975. \$10.00 for all three volumes.

Manuals cover state's recently adopted FLEET (Florida Lifecycle Energy Evaluation Technique) program for controlling energy consumption in state buildings. Energy Conservation Manual provides guidelines for evaluations of building designs in terms of energy conservation and sets energy performance indices (EPI) for wide range of building types. It also provides design standards and performance guidelines for mechanical systems, lighting systems and hot water systems. Life Cycle Analysis Manual outlines FLEET computer program and alternate method for completing required life cycle cost analysis. Manual includes weather data and sample problem. Florida Lifecycle Energy Evaluation Technique Manual describes FLEET programs two main sections—energy estimation and financial analysis—in detail, providing all input specifications, engineering logic, and a sample problem.

Hugh Carter Engineering Corporation. Non-Residential Energy Conservation Standards, Title 24, Economic and Energy Effectiveness Study. Sacramento: State of California Energy Resources Conservation and Development Commission, November 5, 1975.

Mitchell, J.W., et al. Implications of Commercial Building Codes for Energy Conservation. Washington, D.C.: NTIS. December, 1974, No. PB-245 965.

ENERGY CONSERVATION AND BUILDING DESIGN

Aho, Arnold J. Designing With Natural Energies. (Study carried out under grant from Brick Association of North Carolina.)

AIA Research Corporation. Energy Conservation in Building Design. A Report to the Ford Foundation Energy Policy Project, May 1974: \$5.00. (Available from Publications Marketing, The American Institute of Architects, 1735 New York Avenue, N.W., Washington, D.C. 20006.)
Discusses design alternatives for reducing energy consumption, primarily in new buildings. Categories include site analysis; building orientation, configuration, and envelope; space planning, transportation within the building; ventilating, heating, cooling; electric power, lighting; domestic hot water; and waste management. Solar and wind are discussed as alternative energy sources. Energy flow diagrams illustrating variable volume and energy integrated systems for heating and cooling cycles are included. Directed to the architect as well as engineer to respond to the energy crisis.

American Institute of Architects. Energy. (AIA Energy Notebook.) Washington, D.C.: American Institute of Architects, September 1975. (AIA Catalog No. PE-200.)

Berman, Samuel M., and Silverstein, Seth D. Energy Conservation and Window Systems. Washington, D.C.: U.S. Department of Commerce, National Technical Information Service (PB 243 117) January 1975.

A study often quoted by proponents of performance standards, this document is the source of much information on the energy conservation potential of properly-designed glazing systems.

Byrne, Stewart. The Arkansas Story. Owens-Corning Fiberglas Corporation (Report No. 1, Energy Conservation Ideas to Build On), Toledo: 1975.

Brick Institute of America. Walls to Save Energy—A Design Professional's Guide to Energy Conservation with Brick. McLean, VA: Brick Institute of America.

Caudill, William W., et al. A Bucket of Oil: The Humanistic Approach to Building Design for Energy Conservation. Boston: Cahners Books, 1974. \$10.95. (Available from AIA Publications Marketing, 1735 New York Avenue, N.W., Washington, D.C. 20006.)

Calls attention to opportunities and suggests ways for saving energy through building design. Shows how Houston-based architecture-engineering firm of Caudill, Rowlett, Scott have applied the principles presented in the book. Guidelines call for more sensitivity to climatic conditions; frugal use of building materials; task-oriented lighting; designing on edge of comfort zones; efficient HVAC systems; and ample control systems. Advocates performance rather than prescriptive codes.

Dubin, Fred. "Energy for Architects." Architecture Plus, July 1973, pp. 38-49, 74-75.

Egan, M. David. Concepts in Thermal Comfort. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1975. \$10.95.

Presents thermal comfort and mechanical system design concepts for buildings in a graphical format. Covers basic theory of thermal comfort; climatic considerations and architectural responses; building materials; heat loss/gain calculation methods; mechanical systems; and data on mechanical system noise and vibration. Appendices contain useful formulae and tables.

"Enclosure," Architectural Forum, November, 1948.

"Energy and the Builder." Professional Builder, November 1973, pp. 122-51.

Energy Conservation and the Building Shell. Menlo Park, CA: Building Systems Information Clearinghouse of the Educational Facilities Laboratories, Inc., July 1974. \$3.00. (Available from EFL, 3000 San Hill Road, Menlo Park, CA 94025.)

Provides a basic introduction to energy conservation problems and life-cycle cost analysis for school buildings. Attempts to make clear the energy consumption and cost implications of various building design and operating decisions in terms that both the layman and the design professional can understand. Shows how the building shell affects the building's energy consumption; identifies energy-conserving ideas for use in the design (or redesign) of the shell; gives examples showing how these ideas may be applied to new construction and modernization projects. Provides a simple method for determining, during the preliminary stages of the design process, the effects of each of these ideas; and identifies sources of further information to assist design professionals in complete analysis of the effect of the building shell on energy consumption.

Energy Conservation Design Guidelines for New Office Buildings, 2nd edition. Washington, D.C.: The General Services Administration, July 1975. \$2.00. (Available from GSA Business Service Centers.)

This is an updated version of the initial GSA document entitled Energy Conservation Design Guidelines for Office Buildings. Two useful new sections have been added. One outlines the state-of-the-art on solar energy and the other presents an overview of computer software programs on energy conservation design and analysis. The original energy goals (budgets) have been maintained at 55,000 BTU's/gross square foot/year (input at boundary) and 100,000 BTU's/gsf/year (raw source). These figures are now, however, designated in BTU's/equivalent gross square foot/year to account for areas of building requiring energy but not heating and cooling. Numerous guidelines are given for building design, systems and materials selection and building operations. Alternative energy systems and life cycle costing are discussed briefly.

"Family Circle's 'Energy House' Slashes 50% Off Utility Bills." Family Circle, August, 1974, pp. 92-96.

Freed, Robert D. "Cutting Losses at the Top." Mechanix Illustrated, January, 1976, pp. 85, 98.

Griffin C.W. Energy Conservation in Buildings: Techniques for Economic Design. Washington, D.C.: The Construction Specifications Institute, November 1974. \$20.00. (Available from AIA Publications Marketing, 1735 New York Ave., N.W., Washington, D.C. 20006.)

Discusses the economics as well as technical aspects of reducing energy consumption. Cites the financial, political and tax obstacles, and discusses new standards and other energy-conservation measures taken to date. Areas covered are thermal insulation, glass wall design, HVAC; waste-heat reclamation, and architectural techniques for conserving energy. In addition, energy-saving operating procedures, computerized HVAC; control system, lighting and electrical system, and pioneering solar energy applications. Also discussed is the emerging technology of Thermal Energy Storage (TES), and a means of alleviating peak-hour demands on the nation's power utilities. Life-cycle costing is stressed as sound business approach and sane government policy. A brief but informative appendix presents life-cycle concepts and formulae.

"Heat." Architectural Forum, November 1948.

"Here is a House That Cuts Heating and Cooling Bills by 63%." House and Home, October 1975, pp. 68-71.

Hill, James E., and Tamsni Kusuda, "Manchester's New Federal Building: An Energy Conservation Project," ASHRAE Journal, August 1975.

A presentation of the computer energy analysis done by the National Bureau of Standards for the General Services Administration on this energy pilot project. Building design variations and the resultant energy requirements are given for 25 computer runs.

"How Builders Can Cut Heat Loss and Gain in Walls." Professional Builder, February, 1974, pp. 96-101.

"Insulation—The Basic Energy Saver." Professional Builder, Volume II, February 1976.

"Insulation, the Builder's Key to Energy Conservation." Professional Builder, November, 1973, pp. 3-25.

Insulate—Save Energy. San Francisco: Electric and Gas Industries Association.

Lee, Douglas, H.K. Physiological Objectives in Hot Weather Housing. Report for Office of International Affairs, Department of Housing and Urban Development, Washington, D.C.: Department of Housing and Urban Affairs, 1953. Reprinted 1970. (Available from Department of Housing and Urban Development, Office of International Affairs, Washington, D.C. 20410, single copies free.)

The introduction states that "the purpose of this booklet is to present those principles, the observance of which it is believed would minimize the direct effects of hot environments upon man, insofar as housing and shelter can do this." Subjects include the physiological effects on man; basic climatology of tropical and subtropical regions; housing in climates that are hot dry, warm humid or a combination thereof; and functional considerations in housing. Appendix includes a discussion on the heliodon (machine for casting sun shadows); a discussion on psychrometric charts; tables of incidence of solar radiation; formulae for determining temperatures of inner walls; and a list of references.

Lighting and Thermal Operations: Energy Management Action Program for Commercial, Public and Industrial Buildings, 2 vols. Washington, D.C.: Federal Energy Administration, 1974. \$2.30. (Available from U.S. Government Printing Office, Washington, D.C. 20402, no order number.)

One volume contains guidelines on illumination levels, efficiency in lighting and operating heating and cooling systems. A second volume presents a series of nineteen case studies of buildings throughout the U.S. which have institute energy management programs. The case studies provide statistics on energy consumption both before and after the program was implemented.

National Association of Home Builders. The Builders Guide to Energy Conservation. Washington, D.C.: National Association of Home Builders of the United States, 1974.

National Lumber Manufacturers Association. Insulation of Wood-Frame Structures. Washington, D.C.: National Lumber Manufacturers Association, 1964.

National Mineral Wool Insulation Association, Inc. Impact of Improved Thermal Performance in Conserving Energy. New York: March 1973.

Naval Weapons Center. A Program to Evaluate and Demonstrate Conservation of Fossil Fuel Energy for Single Family Dwellings. Prepared for Federal Energy Administration and distributed by National Technical Information Service (PB-245 064), June 1975.

Olgyay, Victor, and Aladar Olgyay. Solar Control and Shading Devices. Princeton, N.J.: Princeton University Press, 1957. (Presently out of print.)

Covers the underlying principles of shading methods in building design. Theoretical aspects of subject are blended with practical applications. Topics include shading devices as architectural elements; technical considerations of solar protection; and actual examples.

Pacific Gas and Electric Company. Ceiling Insulation Program (A report to the California Public Utilities Commission, 1975.)

Peterson, Stephen R. Retrofitting Existing Housing for Energy Conservation. Prepared for the Federal Energy Administration. Washington, D.C.: U. S. Government Printing Office, December 1974.

Pinney, Neil. "Energy Envelope Systems." Energies Magazine, May 1975.

Salter, R.G. and D.N. Morris. Energy Conservation in Public and Commercial Buildings, (P-5093). Santa Monica, CA: Rand Corporation, October, 1973. (Available from Publications Department, Rand Corporation, Santa Monica, CA 90406, single copies free.)

A discussion of the preliminary results of an ongoing study of the use of energy in public and commercial buildings is presented. The effects of building location, design and operation alternatives are developed, together with initial estimates of the conservation potential in the sector. The work is part of Rand's energy conservation work for the National Science Foundation.

Sepsy, C.F., et al. A Study of Attic Temperatures and Heat Loss in Residential Homes. (Prepared for Electric Power Research Institute.) Washington, D.C.: National Technical Information Services, June 1975. (Report No. EPRI 137.)

Spielvogel, Lawrence G. "More Insulation Can Increase Energy Consumption," AHSRAE Journal, January 1974.

Author shows that thermally "heavy" buildings—commercial, industrial and institutional—have an optimum "U" value for their envelopes and that insulating beyond that point can increase energy consumption. Thermally "heavy" buildings are those in which the heating and cooling requirements are not directly proportional to the difference between indoor and outdoor temperatures due to cooling and internal or solar heat gains.

Steadman, Philip. Energy, Environment and Building. A Report to the Academy of Natural Sciences of Philadelphia, Pa. New York: Cambridge University Press, 1975. \$5.95.

A comprehensive survey of methods for the conservation of energy in buildings, and of new sources of energy for building, as well as of ways in which buildings may be designed so as to have a less destructive impact on the natural environment. Subjects include means for energy conservation in otherwise conventionally designed buildings; solar energy and its use for space heating and cooling, for water heating and for the generation of electricity at a building scale through the use of photoelectric cells; the small-scale use of wind and water power; the treatment of building wastes, by composting, and with the production of methane as a fuel, by anaerobic digestion of organic matter; and the conservation of water in buildings. Sets out the basic physical and biological principles involved, but without assuming special technical knowledge on the part of the reader. Shows how these principles can be applied in building design, with illustrations drawn from actual projects.

Stein, Jane. "There Are Ways to Help Buildings Conserve Energy." Smithsonian, pp. 29-33.

Stein, Richard G. "Architecture and Energy." Architecture Forum, August, 1973, pp. 39-58.

Stein, Richard G., and Carl Stein. Research, Design, Construction and Evaluation of a Low Energy Utilization School. A Report to the National Science Foundation, August 1974. \$3.75. (Available from U.S. Government Printing Office, Stock No. 3800-00194.)

First major research project covering the retrofitting of school buildings for energy conservation. Examines the data base of energy consumption patterns compiled by the New York City schools system and attempts to get at characteristics of schools which either utilize large or small amounts of energy compared with the city wide average.

Many surprising results were produced. For example, scaled windowless schools consume up to three times as much energy per square foot than older windowed schools with natural ventilation options, ventilation requirements account for two thirds of the school heating requirements and high even lighting levels had little effect on learning achievement indices. A valuable document for firms dealing with school design.

Stein, Richard. "Some Architectural Implications of Energy Use." AS (Official "Magapaper" of the Association of Student Chapters, American Institute of Architects.) Summer, 1973.

"Stop Housing's Biggest Energy Drain." Professional Builder, April, 1974, pp. 154-58.

Technical Options for Energy Conservation in Buildings. Washington, D.C.: U.S. Department of Commerce, National Bureau of Standards, July 1973, \$2.35. (Available from U.S. Government Printing Office, No. C13.46:789.)

Provides reference material on the technical options for energy conservation in buildings. Lists improvements that can be applied to both existing and new buildings. Applies to commercial institutions as well as residential buildings. Regarding existing buildings: principal topics include summer cooling, winter heating, and other energy-conserving features, i.e., insulation; fenestration, lighting, appliances, domestic hot water, and human comfort. Suggested actions include those which can be accomplished voluntarily or without expense, and also actions which require some modest actions are described that deal with building design and mechanical systems. The report concludes with a summary of mechanisms for implementation of these actions and criterion for use in evaluation of them.

The Builder's Guide to Energy Conservation. Washington, D.C.: National Association of Home Builders, 1974. \$5.00. (Available from NAHB, 15th and M Sts, N.W., Washington, D.C. 20005.)

Covers design considerations, material selection, and construction techniques to achieve energy-efficient houses. An appendix presents operational guides for the homeowner and worksheets for heat loss and cost calculations.

The Economy of Energy Conservation in Educational Facilities. New York: Education Facilities Laboratories, 1973. \$2.00. (Available from EFL, 477 Madison Avenue, New York, NY 10022.)

Covers the basic elements in energy conservation, particularly as they apply to school facilities. Discusses design, operation and maintenance and life-cycle costing for new and retrofitted buildings. Aimed primarily at school administrators, the subject is approached in a literate, non-technical fashion. Several case histories are included.

"Ventilation, Insulation, Key Cost Cutters in Overhead Energy Loss." Professional Builder, June 1974, pp. 128-33.

Watkins, Arthur M. "The Truth About Heat Losses." Mechanix Illustrated, January 1976, pp. 84, 89.

Wedell, Dorothy. "Energy Crunch Prompts Look at Building Design." The San Francisco Examiner, January 6, 1974.

Wells, Malcolm B. "Light and Shiny vs. Thick and Heavy." AS (official "Magapaper" of the Association of Student Chapters, American Institute of Architects). Summer, 1973.

Windheim, Lee Stephen. "A Systems Morphology for Examining Energy Utilization in Buildings." Building Research, July-December 1973, pp. 2-6.

ENERGY CONSERVATION AND BUILDING OPERATION

Berg, C.A., Conservation via Effective Use of Energy at the Point of Consumption (NBSIR 73-202). Washington, D.C.: National Bureau of Standards, April 1973. (Available from Office of Energy Conservation, NBS, Washington, D.C. 20234.)

Methods of conserving energy at the point of consumption are explored. Some examples of opportunities for improving effectiveness of energy consumption in buildings are discussed under three general areas: design (including insulation, fenestration, selection of heating and ventilating equipment, etc.); construction practices in implementing design; and occupant practices in using buildings. Industrial energy consumption has not been studied thoroughly. Many fairly simple measures, such as plugging leaks in air and steam lines and furnishing steam at the required temperatures and pressures, could result in considerable energy conservation. Data are cited to support the belief that the practices and equipment used in various industries could be substantially improved to conserve energy, and in many cases the improvements would be economically justified. Additional information on ways to conserve energy coupled with more effective technology of materials and machinery should result in substantial energy savings in both the residential and industrial sectors.

Department of Commerce. How to Start an Energy Management Program. Washington, D.C.: U.S. Government Printing Office, 1973.

Department of Commerce. 33 Money Saving Ways to Conserve Energy. Washington, D.C.: U.S. Department of Commerce, November, 1973.

Federal Energy Administration. An Energy Handbook for Small Businesses. Washington, D.C.: U.S. Government Printing Office, 1973.

Federal Energy Administration. A Pilot Project in Homeowner Energy Conservation. Final Report. Washington, D.C.: Federal Energy Administration, October 31, 1974.

Federal Energy Administration. Lighting and Thermal Operations, Energy Management Action Program for Commercial-Public-Industrial Buildings, Guidelines. Washington, D.C.: U.S. Government Printing Office, 1974.

Federal Energy Administration. Tips for Energy Savers in and Around the Home, on the Road, in the Marketplace. Washington, D.C.: Federal Energy Administration, 1974.

Gatts, Robert R.; Massey, Robert G.; and Robertson, John C. Energy Conservation Program Guide for Industry and Commerce (EPIC). Washington, D.C.: Institute for Applied Technology, National Bureau of Standards, U.S. Department of Commerce, September 1974.

Energy Conservation for Existing Office Buildings. Washington, D.C.: The General Services Administration, February 1975. \$2.00. (Available from GSA Business Service Centers.)

Covers the issues and opportunities for achieving energy conservation in existing office buildings through renovation and remodeling. An energy goal of 75,000 btu/gross square foot/year for input at the building boundary is established, regardless of location in the country. A goal of 150,000 btu/gross square feet/year for raw energy source is suggested. The approach of this document follows that of the GSA guidelines on new buildings. A series of suggested design and operational guidelines are given for site, building elements, HVAC, lighting, power and other systems. A brief discussion of life cycle costing is included.

Guidelines for Energy Conservation in Existing Buildings. Arlington, VA: Sheet Metal and Air Conditioning Contractors' National Association, Inc., September, 1974.

Hittman Associates, Inc. Residential Energy Conservation, prepared for the Department of Housing and Urban Development (HUD-HAI-8). Washington, D.C.: Department of Housing and Urban Development, July, 1974.

In the Bank...Or Up the Chimney? Washington, D.C.: U.S. Department of Housing and Urban Development, 1975. \$1.70 (Available from U.S. Government Printing Office, Stock No. 023-000-00297-3).

Manual is oriented to homeowner on how energy can be saved through a variety of home improvements. Provides description of opportunities for increasing thermal efficiency and offers simple charts for calculating dollar costs as well as savings. Large illustrated section on how homeowner can do things himself. Aimed at consumer but could be useful to architects involved in housing.

Konzo, Seichi, and Shick, Wayne L. Living with the Energy Crisis. Small Homes Council-Building Research Council, University of Illinois, Circular Series Index Number C1-5 (University of Illinois Bulletin, Volume 70, Number 144, July 30, 1973).

National Bureau of Standards, U.S. Department of Commerce. 11 Ways to Reduce Energy Consumption and Increase Comfort in Household Cooling. Washington, D.C.: NBS Publication No. 5-BL 5439.

Pacific Gas and Electric Company. The Meter Minder's Guidebook. San Francisco: Pacific Gas and Electric Company, February 1974.

Schipper, Lee. Holidays, Gifts and the Energy Crisis. Berkeley: Lawrence Berkeley Laboratory/Department of Physics and Energy and Resources Program, University of California, November 25, 1974.

Schoenfelder, James. "Improving the Energy Efficiency of Buildings." (from an unidentified periodical.)

"Some Hints on How to Cut Energy Use 10%." P G and E Progress. January 1974, pp. 1-2.

Southern California Gas Company. Energy Conservation on a Practical Level. Los Angeles: Southern California Gas Company.

Southern California Gas Company. How to Save Energy in Commercial Buildings. Los Angeles: Southern California Gas Company.

Spielvogel, Lawrence G. "Exploding Some Myths About Building Energy Use," Architectural Record, February, 1976, pp. 125-28.

The Institute of Real Estate Management. Energy Conservation Recommendations. Chicago: The Institute of Real Estate Management, December, 1975.

Vragel, Kurt. How to Save Energy in Your Home. Denver: Kurt Vragel Associates, Inc., 1975.

ECONOMICS OF ENERGY CONSERVATION IN BUILDINGS

Ackerman, Allan D., et al. Cost Effective Methods to Reduce the Heating and Cooling Energy Requirements of Existing Single Family Residences. (Prepared for Department of Housing and Urban Development.) Washington, D.C.: National Technical Information Service, February, 1975.

Brazil, John, and Magee, John. Design and Cost Tradeoffs in Heavily Insulated Solar Heated and Cooled Homes. Los Gatos, CA: By the author (18340 Black Road, Los Gatos, CA 18340), undated.

Ruegg, Rosalie T., Solar Heating and Cooling in Buildings: Methods of Economic Evaluation. Washington, D.C.: U.S. Department of Commerce, National Bureau of Standards (COM-75-11070 and NBSIR 75-712), July 1975.

Retrofitting Existing Housing for Energy Conservation: An Economic Analysis. Washington, D.C., National Bureau of Standards in cooperation with the Federal Energy Administration 1974. \$1.35 (Available from U.S. Government Printing Office, Washington, D.C. 20402. Catalog No. C13.29:2/64).

An economic model utilizing marginal analysis is generated to determine the optimal combination of energy conservation techniques for achieving effective utilization of resources as well as energy and dollar savings. Energy conservation techniques covered include insulation, storm windows and doors, and weather-stripping. Highly technical.

COMPUTER PROGRAMS FOR BUILDING ENERGY ANALYSIS

Cuccinelli, Kenneth T., and Lobert, Thomas J. "E Cube, Energy Conservation Utilizing Better Engineering." American Gas Association Monthly, October, 1973.

Hill, J.E., Kusada, T., Liv, S.T., and Powell, F.J. A Proposed Concept for Determining the Need for Air Conditioning for Buildings Based on Building Thermal/Response and Human Comfort. Washington, D.C: National Bureau of Standards, August, 1975.

Parish, Thomas H. "E CUBE, Use in Residential Energy Analysis." American Gas Association Monthly, January 1974.

Rogers-Nagel-Langhart. Energy Conservation Study (for design of the Colorado State Judicial/Heritage Center Complex), Rogers-Nagel-Langhart, Denver, Colorado.

Skurkis, Daniel M. "E CUBE: Can It Fight the Real Battle?" Actual Specifying Engineer, August, 1972.

U.S. Department of HUD. Verification of the Time-Response Method for Heat Load Calculation. Report No. HUD-HAI-5. August, 1973.

Comarc Design Systems. C4 Heat—A Program to Calculate the Heat Loss, or Heating Load, for Buildings. San Francisco: TymShare, March 1972.

ENERGY CONSERVATION OPPORTUNITIES IN LANDSCAPING

Dahlin, Dennis. The Greedy Lawn, Berkeley, CA: by the author, 1975.

Deering, R.B. "Effective Use of Living Shade." California Agriculture, September, 1955, p. 10.

Deering, R.B., and Brooks, F.A. "Landscaping for Summer Shade." California Architecture, 7(5). 11, 16, 1953.

Neubauer, L.W., House Comfort in Hot Weather, Preliminary Report on Orientation and Shading. Davis, CA: University of California Department of Agricultural Engineering, January 27, 1956.

Neubauer, L.W. House Cooling in a Warm Dry Climate. Davis, CA: University of California Department of Agricultural Engineering, October 20, 1955.

Neubauer, L.W. and Cramer, R.D. Solar Radiation Control for Small Exposed Homes. Chicago: Presented at the 1959 Winter Meeting of the American Society of Agricultural Engineers, December, 1959.

Robinette, Gary. Plants, People and Environmental Quality. Washington, D.C.: U.S. Government Printing Office, 1972.

ENERGY CONSERVATION IN AGRICULTURE

Cervinka, V., et al. Energy Requirements for Agriculture in California. Joint study by California Department of Food and Agriculture and University of California at Davis, January, 1974.

Pacific Gas and Electric Company. Saving Energy on the Farm. San Francisco: Pacific Gas and Electric Company, September, 1974.

CLIMATE

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.,—Golden Gate Chapter. Recommended Outdoor Design Temperatures, Northern California. ASHRAE Bulletin TB 65-1. March 1965.

ASHRAE Handbook of Fundamentals. New York: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1972.

Givoni, B. Man, Climate and Architecture. New York: Elsevier Publishing Company, Ltd., 1969. (Currently out of print.)

Presents a balanced discussion on the physiological, the physical and architectural aspects of the relationship between climate, man and architecture. Major subjects include climatic elements and their effect on man; thermophysical properties of building materials, impact of solar radiation; ventilation problem; and an integrated application of subjects covered for different climatic regions. The emphasis on hot climates reflected in the work is due to the author's long time research work in that area.

"Microclimatology." The Architectural Forum. March, 1947, pp. 114-19.

Olgay, Victor. Design With Climate: Bioclimatic Approach to Architectural Regionalism. Princeton, N.J.: Princeton University Press, 1963. \$25.00.

A classic work emphasizing the need for regionalized architectural solutions accomplished by scientific analysis and response to climatic conditions. The first part of the work covers concepts and principles including effects of climate on man, comfort and regional evaluation. The second part begins to develop approaches for achieving effective architectural principles. This includes site selection, solar control, wind studies and use of materials. The last part deals with creating design solutions in four climatic regions.

Pacific Gas and Electric Company. Mean Hourly Temperatures—for Northern and Central California. San Francisco, PG&E, 1967.

"Regional Climate Analysis Design Data: The House Beautiful Climate Control Project." Bulletin of the American Institute of Architects, September 1949-January 1952. (Available from Xerox University Microfilms, 300 North Zeeb Road, Ann Arbor, MI 48106. Softcover reprint \$15.00 plus postage; microfilm \$5.00 plus postage.)

This series of reports presents climatological and design data on a regional basis for 15 population nodes through the country. Includes weather data on temperature, sun, wind, and precipitation. Design responses cover site, interior plan, roof and wall openings, foundations and basements and mechanical. The emphasis of the project is on residential construction but the climatological data and the design guidelines can be applicable for other building types. The need for regionalized environmental responses is stressed. An excellent document. (A nontechnical overview of the Climate Control Project is contained in the October 1949 issue of House Beautiful.)

Solar Radiation Measurements in California. Sacramento: State of California Department of Water Resources, Division of Resources Development, January 1974.

U.S. Department of Commerce. Monthly Normals of Temperature, Precipitation and Heating and Cooling Degree Days 1941-70—California. No. 81. August, 1973.

U.S. Department of Housing and Urban Development. The Applicability of the Residential Energy Consumption Analyses to Various Geographic Areas. Report No. HUD-HAI-6. November, 1973.

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